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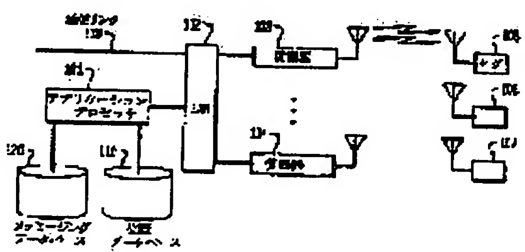
(54) COMMUNICATION SYSTEM

(57)Abstract:

PROBLEM TO BE SOLVED: To improve the security and to reduce the cost of a communication system by transmitting the information at one or more data speeds by means of a modulation back scatter technique.



SOLUTION: An application processor 101 communicates with the question units 103 and 104 via a LAN(local area network) 102. Every question unit communicates with one or plural tags 105 to 107. A receiving modulation radio signal modulator can recover a 1st information signal, and a 1st decision element supplies the output to designate at least the selected one of two alternate actions A and B in response to the 1st information signal. A 2nd information signal is produced in response to the output of the 1st decision element and has a data speed which is increased in the action A compared with the action B. Then the reflection of a receiving modulation radio signal is modulated by means of the 2nd information signal.

【外国語明細書】

1 Title of Invention

Communication Device

2 Claims

1. A communication device, comprising:
a demodulator of received modulated radio signals, operable for recovery of at least one First Information Signal;
a first decision element, responsive to the First Information Signal, adapted to provide an output that indicates a selected one of at least two alternative actions, to be referred to as Action A and Action B;
a display device adapted to display at least a portion of the First Information Signal;
a signal-generating device adapted to generate a Second Information Signal in response to the output of the decision element, wherein the Second Information Signal has a data rate, and said data rate is greater when Action A is indicated than when Action B is indicated; and
a backscatter modulator adapted to modulate reflections of the received modulated radio signals, using the Second Information Signal.

2. The device of claim 1, further comprising:
a subcarrier signal generator; and
a modulator adapted to modulate the subcarrier signal with the Second Information Signal, thereby to form a modulated subcarrier; and wherein:
the backscatter modulator is adapted to modulate reflections of the received modulated radio signals with the modulated subcarrier.

3. The device of claim 2, wherein the modulator is responsive to the first decision element, such that the modulated subcarrier for Action B is a pure unmodulated tone at the frequency of said subcarrier.

4. The device of claim 1, further comprising at least one pushbutton, and wherein the signal-generating device is response to said at least one pushbutton, such that at least some contents of the Second Information Signal are determined, at least in part, by depression of at least one said pushbutton.

5. The device of claim 1, further comprising:
at least one pushbutton; and
a second decision element adapted to provide an output that indicates whether the Second Information Signal should be transmitted; and wherein:

the second decision element is responsive to at least one said pushbutton such that depression of at least one said pushbutton leads to an indication that the Second Information Signal should be transmitted.

6. The device of claim 1, further comprising an alarm, and means for activating the alarm based upon contents of the First Information Signal.

7. The device of claim 1, further comprising a storage medium for storing at least a portion of the First Information Signal.

8. The device of claim 1, further comprising means for generating at least a portion of the Second Information Signal from data stored within said communication device.

9. The device of claim 1, further comprising a stored record of biometric data pertaining to a holder of said communication device, and wherein the signal-generating device is adapted to include at least some of said data in the Second Information Signal.

10. The device of claim 1, further comprising:
an energy-transfer element; and
an energy-storage element that is rechargeable through the energy-transfer element.

11. The device of claim 10, wherein the energy-transfer element comprises a coil.

12. The device of claim 10, wherein the energy-storage element comprises a capacitor.

13. The device of claim 1, further comprising a solar cell and an energy storage device chargeable from the solar cell.

14. The device of claim 1, further comprising:
a signal processor having a sleep mode and a waking mode; and

means for regularly awakening the processor from the sleep mode.

15. The device of claim 1, further comprising:
a signal processor having a sleep mode and a waking mode; and
a radio-frequency (RF) detector, wherein:
the signal processor is responsive to the RF detector such that when the presence of an RF field is detected, the signal processor is awakened from the sleep mode.

16. The device of claim 1, further comprising:
a graphic; and
an antenna at least partially situated beneath the graphic.

17. The device of claim 1, further comprising:
a graphic; and
an energy transfer device at least partially situated beneath the graphic.

18. The device of claim 16 or claim 17, wherein the graphic is a picture of a holder of said communication device.

19. The device of claim 16 or claim 17, wherein the graphic is a company or organizational logo.

20. The device of claim 1, further comprising:
a plurality of pushbuttons constituting a mathematical keyboard; and
a microprocessor in receiving relationship to the pushbuttons, the microprocessor adapted to perform at least some mathematical operations in response to manipulations of the pushbuttons, and to display results of such operations on the display device.

21. The device of claim 1, further comprising:
at least one pushbutton for designating an emergency mode; and
means, responsive to the pushbutton, for executing an emergency mode upon receipt of the next First Information Signal after an emergency mode has been designated; wherein:

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the signal-generating device is responsive to the emergency-mode executing means, such that when the emergency mode is executed, a Second Information Signal is generated containing data indicating an emergency condition.

3 Detailed Description of Invention

Field of the Invention

This invention relates to wireless communication systems and, more particularly, to an in-building or campus area wireless communication system using modulated backscatter technology.

Background of the Invention

Security access systems have been developed to support the automatic identification of personnel, for example to authorize the entrance of an employee into a building. (In this application, we use the term "employee" to mean the person to whom we wish to provide service. Other applications of the invention disclosed here exist in which the receiver of the service is not an "employee", but that term is convenient and we will use it.) Examples of such systems include the provision of a distinctive employee identification badge, perhaps with the employee's picture printed on the badge, which is examined by a guard to determine if access to the

building is authorized. A next logical step is for the employee to carry an identification card which electronically authorizes entrance to the building. For example, "magnetic" key cards exist which are keyed with a particular magnetic signature; and which, when held in close proximity to a magnetic reader, can authorize building entrance. Another example is a card with a magnetic stripe on the back (such as a magnetic stripe used on the back of a credit card); the employee then "swipes" the card through a card reader to authorize building entrance. Still another example of the same concept is a "Smart Card" in which the card is placed either into or on top of an electronic reader which can access data stored on the Smart Card, and this data is the means to authorize building entrance. Recent trends are emphasizing the use of magnetic key cards, magnetic stripe cards, or Smart Cards in order to allow building entrances to be unstaffed, and therefore to reduce costs.

Radio Frequency Identification (RFID) systems represent the next logical evolution in the technologies discussed above. RFID is used for identification and/or tracking of equipment, inventory, or living things. RFID systems are radio communication systems that communicate between a radio transceiver, called an Interrogator, and a number of inexpensive devices called Tags. In RFID systems, the Interrogator communicates to the Tags using modulated radio signals, and the Tags respond with modulated radio signals. In one RFID technique, the Interrogator first transmits a message to the Tag (called the Downlink); then the Interrogator transmits a Continuous-Wave (CW) radio signal to the Tag. The Tag modulates the CW signal using modulated backscattering where the antenna is electrically switched, by the modulating signal, from being an absorber of RF radiation to being a reflector of RF radiation. This Modulated BackScatter, or MBS, allows communications from the Tag back to the Interrogator (called the Uplink). RFID is used today in the security industry to facilitate building access; for example, the use of an RFID Tag to automatically authorize entrance to a building, and/or to record that an individual passed by a particular location. This operation is called the Interrogation Mode; it is a mode of operation in which the Interrogator transmits a signal to all Tags in the reading field, requesting those Tags to respond with data which identifies this Tag. The Tag then transmits this information back to the Interrogator using MBS.

RFID technology represents a considerable improvement over the other building access technologies discussed above. The other technologies have limited range (typically a few inches or less) between the reading device and the card or badge. This limited range requires the employee to place the card or badge in close proximity to the reading device. RFID technology allows this range limitation to be relaxed, at least to some degree, and in some cases relaxed altogether. Some RFID

technologies are inherently short range (i.e., effective range of a foot or two), while other RFID technologies support an Interrogation Mode range exceeding ten feet. This latter range is capable of providing a truly "hands free" operation where the RFID Tag does not have to be removed and held close to the reading device in order to be read.

Beyond the security applications discussed above, employees within a building or campus environment have other needs as well. (For the remainder of this disclosure, we use the term "building" or "in-building" to mean either within a building or within a campus environment which could include a building.) For example, "Location" applications also exist. It is beneficial to know the location of a specific Tag within the building, especially in high-security buildings. Prototype systems, using infrared transmitters, have been developed to allow the location of a "Tag" to be tracked; however there are no commercial products, and infrared technology suffers from lack of range and no ability to pass through objects. For example, if the infrared transmitter is placed inside a person's shirt pocket, the communications path is blocked. For large, expensive items, such as a tractor used in long-distance trucking, it may be cost-effective to place a Global Positioning System (GPS) receiver in the tractor; thus, the position of the tractor can be determined. However, GPS receivers are expensive, not suitable for use by individuals, and not designed for in-building applications. Therefore, there are today no cost-effective solutions to the location problem for individuals within a building or campus environment.

In addition, low speed data "Communications" applications are also present. Let us assume that an employee receives a very important phone call, but the employee is not in his/her office at the time the call is received. About the only reasonable option today is for a secretary to take the call and attempt to find the employee. Let us further assume that an employee receives a very important electronic mail message. Systems are in existence today that allow the electronic mail system to interconnect with a "Paging" system, so that all or part of the electronic mail message appears on the display of the pager. Today, Paging is the most commonly used mechanism to support low speed wireless data communications. However, there are drawbacks to the use of Paging systems. Some Paging systems suffer from poor in-building wireless coverage. Also, some Paging services involve paying usage charges to a service provider on a per-transaction basis. Within a building or campus environment, it is possible to deploy a wireless data LAN; however these products are still relatively expensive. Therefore, low-cost solutions do not exist today for low speed wireless data communications

within a building or campus environment.

Therefore, we have seen that RFID technology, which is inherently a low-cost technology, is making inroads into security applications for the purpose of identifying Tags as they pass a specific reading device. However, there are no low-cost techniques to provide location information within a building or campus environment, and there are no low-cost techniques to provide low speed wireless data communications information within a building or campus environment. There are also no systems that integrate the above capabilities -- Interrogation, Location, and Low Speed Wireless Data Communications (or Messaging) -- in one system. In this invention, we disclose the design of a low cost personal communications device, utilizing modulated backscatter. This device can be used to integrate the functions of Security, Location, and Messaging in a single system with a single infrastructure. This device thus can provide improved security as well as cost-effective in-building or campus-area location and communications services.

Summary of the Invention

In accordance with the present invention, a radio personal communications device is disclosed, which is capable of receiving modulated radio signals, and capable of transmitting modulated radio signals using modulated backscatter technology. This device can operate in an Interrogation Mode, in which a set of mandatory data is transmitted from the device; in a Location Mode, in which the approximate location of the device can be determined, and in a Messaging Mode, in which data can be transmitted to and received from the device. The device is capable of transmitting information, using modulated backscatter, at more than one data rate. The device contains a display to display some or all of the data transmitted to the device. Alternate embodiments of the invention allow the device to also support pushbuttons to allow data to be input to the device. Alternate embodiments support a variety of powering mechanisms for the device, including batteries, charge storage devices, solar cells, a coil or other energy transfer device, etc. A recharging station is also disclosed in the event the power supply of the device requires recharging.

Brief Description of the Drawing

In the drawing,

FIG. 1 shows a block diagram of an illustrative Radio Frequency Identification (RFID) system;

FIG. 2 shows a block diagram of an illustrative Interrogator Unit used in the RFID system of FIG. 1;

FIG. 3 shows a block diagram of a Tag Unit used in the RFID system of FIG. 1;

FIG. 4 shows a block diagram of a Personal Pager and IDentifier (PPID);

FIG. 5 shows one embodiment of the physical layout of a PPID;

FIG. 6 shows an alternate embodiment of the physical layout of a PPID;

FIG. 7 shows an RF Detector incorporated in a PPID;

FIG. 8 shows a Docking Station and how the PPID could be oriented with respect to the Docking Station.

Detailed Description

MBS Operation

We now describe how a typical RFID system, utilizing MBS, operates. With reference to FIG. 1, there is shown an overall block diagram of a traditional RFID system. An Applications Processor 101 communicates over a Local Area Network (LAN, 102), which could be wired or wireless, to a plurality of Interrogators (103, 104). The Interrogators may then each communicate with one or more of the Tags (105, 107). For example, the Interrogator 103 receives an information signal, typically from an Applications Processor 101. The Interrogator 103 takes this information signal and Processor 200 properly formats a Downlink message (Information Signal 200a) to be sent to the Tag. With joint reference to FIGS. 1 and 2, Radio Signal Source 201 synthesizes a radio signal, the Modulator 202 modulates this Information Signal 200a onto the radio signal, and the Transmitter 203 sends this modulated signal via Antenna 204, illustratively using amplitude modulation, to a Tag. The reason amplitude modulation is a common choice is that the Tag can demodulate such a signal with a single, inexpensive nonlinear device (such as a diode).

In the Tag 105 (see FIG. 3), the Antenna 301 (frequently a loop or patch antenna) receives the modulated signal. This signal is demodulated, directly to baseband, using the Detector/Modulator 302, which, illustratively, could be a single Schottky diode. The result of the diode detector is essentially a demodulation of the incoming signal directly to baseband. The Information Signal 200a is then amplified, by Amplifier 303, and synchronization recovered in Clock Recovery Circuit 304. The Clock Recovery Circuit 304 can be enhanced by having the

Interrogator send the amplitude modulated signal using Manchester encoding. The resulting information is sent to a Processor 305. The Processor 305 is typically an inexpensive 4 or 8 bit microprocessor; the Clock Recovery Circuits 304 can be implemented in an ASIC (Application Specific Integrated Circuit) which works together with or is incorporated within the integrated circuit containing Processor 305. This Processor 305 can also serve as the driver for an optional Display Unit 309 should this Tag require a display. The Processor 305 generates an Information Signal 306 to be sent from the Tag 105 back to the Interrogator (e.g., 103). This Information Signal 306 is sent to a Modulator Control Circuit 307, which uses the Information Signal 306 to modulate a subcarrier frequency generated by the Frequency Source 308. The Frequency Source 308 could be a crystal oscillator separate from the Processor 305, or a signal derived from the output of a crystal oscillator, or it could be a frequency source derived from signals present inside the Processor 305 – such as a multiple of the fundamental clock frequency of the Processor. The Modulated Subcarrier Signal 311 is used by Detector/Modulator 302 to modulate the modulated signal received from Tag 105 to produce a modulated backscatter (i.e., reflected signal). This is accomplished by switching on and off the Schottky diode using the Modulated Subcarrier Signal 311, thereby changing the reflectance of Antenna 301. A Battery 310 or other power supply provides power to the circuitry of Tag 105.

There are a variety of techniques for using Modulated Backscatter (MBS) to send information from the Tag to the Interrogator. In some MBS technologies, the Modulator Circuit 307 of the Tag generates a modulated signal, which is amplitude modulated by an Information Signal 306 at frequency f_2. If the Radio Signal Source 201 generates an unmodulated frequency f_1, then the Interrogator receives signals inside of the range $(f_1 - f_2)$ to $(f_1 + f_2)$, and generally filters out signals outside of that range. This could be termed the "MBS at baseband" approach. Another approach would be for the Tag to generate two different subcarrier frequencies. The information could be conveyed in a frequency-shift keyed (FSK) fashion with the subcarrier frequency transitioning between these two frequencies. Other modulation schemes are possible as well, such as Phase Shift Keying (PSK) of a single subcarrier frequency (e.g., BPSK, QPSK) or other complex modulation schemes (e.g., MFSK, MASK, etc.).

Returning to FIG. 2, the Interrogator 103 receives the reflected and modulated signal with the Receive Antenna 206, amplifies the signal with a Low Noise Amplifier 207, and demodulates the signal using homodyne detection in a Quadrature Mixer 208. (In some Interrogator designs, a single Transmit (204) and

Receive (206) Antenna is used. In this event, an electronic method of canceling the transmitted signal from that received by the receiver chain is needed; this could be accomplished by a device such as a Circulator.) Using the same Radio Signal Source 201 as used in the transmit chain means the demodulation to baseband is done using Homodyne detection; this has advantages in that it greatly reduces phase noise in the receiver circuits. The Mixer 208 then sends the Demodulated Signal 209 (if a Quadrature Mixer, it would send both I (in phase) and Q (quadrature) signals) to the Filter/Amplifier 210. The resulting filtered signal -- which in this invention is an Information Signal 211 carried on a subcarrier -- is then demodulated from the subcarrier in the Subcarrier Demodulator 212, which then sends the Information Signal 213 to a Processor 200 to determine the content of the message. The I and Q channels of Signal 209 can be combined in the Filter/Amplifier 210, or in the Subcarrier Demodulator 212, or they could be combined in the Processor 200.

Using, e.g., the above techniques, a short-range, bi-directional digital radio communications channel is implemented. A relatively inexpensive implementation is achieved using, as exemplary components, a Schottky diode, an amplifier to boost the signal strength, bit and frame synchronization circuits, an inexpensive 4 or 8 bit microprocessor, subcarrier generation circuits, and a battery. Most of these items are already manufactured in quantities of millions for other applications, and thus are not overly expensive. The circuits mentioned above for bit and frame synchronization and for subcarrier generation can be implemented in custom logic surrounding the microprocessor core; thus, except for a relatively small amount of chip real estate, these functions come almost "for free."

Narrowband Operation

Using the above procedures, a two-way digital radio communications channel can be constructed. We desire to extend the range of this two-way digital radio communications channel as much as possible. This involves both extending the range of the Downlink and also extending the range of the Uplink.

Extending the range of the Downlink involves several factors. The Downlink is generally an amplitude modulated signal, which is easily and inexpensively detected by a single nonlinear device, such as a microwave diode. It is important to match the impedances between the antenna and the diode to avoid gratuitous signal attenuation. The data rate of the Downlink must be limited in order to reduce the noise bandwidth of the Downlink signal. We now discuss how the Tag can filter out unwanted signals without increased cost. The Antenna (301) not only performs the tasks of receiving the RF signal, but it also filters RF signals outside of

the antenna bandwidth. For example, at 2.45 GHz, allowable RF carrier frequencies are from 2.400 - 2.485 GHz. The design of the antenna, frequently a patch antenna, covers this frequency band but filters out frequencies beyond this range. An ideal frequency response would be for the antenna sensitivity to be within 3 dB across the allowable frequency range, but to fall off rapidly beyond this range. In addition, the Amplifier (303) also acts as a filter in the sense that the Amplifier is designed to only pass Amplitude Modulated (AM) signals that are within a certain passband around the expected Downlink data rate, which is typically a few kilobits per second. Therefore, although the Tag is relatively simple, it has filtering capability to filter out both RF signals whose frequency is outside the Antenna bandwidth, and also to filter out AM signals whose frequency is outside of the Amplifier passband. This Tag design is also not greatly sensitive to RF transmissions, inside the band of the antenna, whose modulation scheme is primarily constant envelope. Thus, this design allows a robust Tag which is resistant to many potential interfering signals.

Extending the range of the Uplink also involves several factors. First, the noise bandwidth of the Uplink signal must be reduced as much as possible. A number of useful applications can be implemented even if the data rate of the Uplink signal is limited to a few bits per second. Indeed, this limitation of the data rate can be taken to the extreme in which there is no data modulated onto the single subcarrier frequency; in this case, the mere presence or absence of a signal received at this subcarrier frequency indicates an "acknowledgment" or "no acknowledgment" to a previously received message. We further note that the subcarrier frequency can be relatively accurately determined. For example, commercially available crystals exist with a frequency of 32kHz, and an accuracy of ± 100 ppm. Thus, the frequency of this crystal is known to ± 3.2 Hz. The Tag thus generates a subcarrier frequency, f_s, of great accuracy. The Interrogator receives the reflected signal, and demodulates it as discussed above using Homodyne detection. The Filter Amplifier (210) and Subcarrier Demodulator (213) function could then be implemented, together, inside a processor such as a DSP. Narrowband filtering algorithms exist in the literature which can perform digital filtering of the signal with a bandwidth of less than 10 Hz, and where the first sidelobes are depressed 60 dB. Then, the signal strength of the signal received through this digital filter is measured, and that strength is compared to a reference signal strength which is sufficiently above the average noise in that channel when no signal is present such that spurious noise spikes are not misinterpreted as actual signals. In this manner, very weak Uplink signals can be reliably detected. It has been found that, using these techniques, roughly equivalent range in the Downlink and the Uplink can be achieved.

We now discuss the location of the subcarrier frequency f_s. MBS systems exhibit noise in the Uplink signals due to reflections of the RF source from any number of reflectors. Walls and metal objects reflect RF radiation; these reflected signals are received by the Interrogator 103 at the same carrier frequency as they were transmitted. The Quadrature Mixer 208 is operated as a Homodyne Detector and thus is used to cancel these reflections. However, other reflectors generate reflected noise at frequencies away from the main carrier frequency - either from Doppler shifts or, more likely, from reflections off of electronic equipment operating at frequencies near the Subcarrier Frequency. One particularly difficult source of noise is fluorescent lights, which have been shown to produce noise not only at their fundamental 60 Hz (in the United States) frequency, but also at overtone frequencies well up into the tens of thousands of Hertz. It has been found especially helpful to locate the subcarrier frequency f_s such that it falls between multiples of the fundamental 60 Hz frequency. From the 32 kHz crystal, simple circuits can generate the appropriate subcarrier frequency.

Multiple Mode Operation

The basic features of multiple mode operation are that a) the Tag must be capable of receiving a Downlink message; b) the Tag must be told what type of Uplink message it is to transmit, whether it be an actual data message (higher bit rate mode) or a simple acknowledgment message (long range mode), based upon information received in the Downlink message; c) the Tag transmits the requested type of Uplink message; and d) the Interrogator interprets the Uplink message received in a proper manner. Several different types of acknowledgment messages in the long range mode can exist. Generally, an acknowledgment message has a data rate which is much less than the data rate of an actual data message (the higher bit rate mode), thus allowing filtering over a much smaller frequency band, and thus allowing greater range than the higher bit rate mode since the noise bandwidth of the received signal is lessened due to the narrowband filtering. Thus, an acknowledgment message could consist of a low bit rate data message, or it could consist of a single bit of information. As discussed above, to send a single bit of information, the Tag could generate an unmodulated subcarrier frequency which could be modulated onto the incident signal, using modulated backscatter. The Interrogator would then receive a reflected signal with a single frequency tone. Narrowband filtering techniques could then be used to reduce the noise bandwidth and determine the presence or absence of this signal.

The Tag 105 detects and assembles the bits of information sent from the Interrogator 103 into a complete Downlink message. Typically, a pattern of synchronization bits is transmitted at the beginning of the Downlink message; these bits allow the Tag to acquire bit and message synchronization; enabling the Tag to determine the beginning and the end of the Downlink message. The Downlink message contents would include an Address, a Command, optionally include Data, and also include Error Detect. The Command or Data portion of the Downlink message could indicate that the Tag 105 should return a Message to the Interrogator; for example, the Tag could return stored data, such as the Tag ID, or other application-specific data. Another type of Downlink message could indicate that the Tag should send back only a single-bit acknowledgment message.

Thus, the Processor 305 of the Tag 105 determines, in response to information in the Downlink message, what type of Uplink signal to transmit: a data message or a simple acknowledgment message. There are several ways that the Tag 105 may transmit either a data message or a simple acknowledgment message so that the Interrogator 103 can, relatively easily, receive and distinguish between these two different types of messages. Referring to FIG. 3, in the event that the Tag 105 is to send a multi-bit information signal, Processor 305 sends the Information signal to the Modulator Control 307, which modulates the signal from Subcarrier Frequency Source 308.

In Tag 105, Processor 305 sends the Information Signal over the Information Signal Lead 306 shown in FIG. 3. In the event that Processor 305 of Tag 105 is to send a "single tone" message consisting of a single information bit, the Information Signal Lead 306 is maintained at a first logic state to indicate that no information message is to be sent. Thus, an unmodulated subcarrier frequency signal is outputted by Modulator Control 307. In the event that Processor 305 determines that a multi-bit message is to be sent, the Information Signal Lead 306 conveys the multi-bit message to Modulator Control 307. This multi-bit message (information signal) is then used to modulate the subcarrier frequency using one of several possible modulation techniques, such as amplitude, phase, frequency, or code modulation.

The Interrogator 103 (FIG. 2) demodulates the subcarrier signal from the received RF signal, and then applies filtering. Given the specifics of the subcarrier frequency, a suitable filtering amplifier is utilized. Subcarrier Demodulator 212 then demodulates the subcarrier signal. The Processor 200 then performs the digital signal processing necessary to decode the information. In some implementations of this invention, the Processor may be a Digital Signal Processor

(DSP); in others, a conventional Microprocessor could be used. To recover a "single tone" acknowledge signal from Tag 105, consisting of a single subcarrier tone, the filtering amplifier would be a narrowband filter. While conventional filter technologies could be used, it may be most effective to utilize the DSP mentioned above as a narrowband filter. The subcarrier frequency of this single tone is well known; as the Tag 105 would typically use an inexpensive crystal as the frequency source. Even with the limited accuracy of that crystal, the subcarrier frequency could be known to an accuracy of a few Hertz. Thus, very narrowband filters could be used. Since the acknowledge signal response from Tag 105 is used to extend the range of the RFID system and consequently would likely be a very faint signal, it places an additional burden on the narrowband filter of filtering amplifier 210.

Another way that the DSP mentioned above could be used is to dynamically search for the frequency components of the Uplink signal. This could be accomplished by performing a Fourier Transform on the incoming data stream, perhaps using a DSP, or using Processor 200 of FIG. 2. In this manner, the multiple signals representing a modulated subcarrier signal could be differentiated; or, a single subcarrier signal of uncertain data rate could be recovered by using the Fourier Transform to search for multiple signals.

Thus, we have shown how a modulated backscatter communication system can operate in two modes - one in which the backscattered signal is modulated to provide a high data rate Uplink communication channel, and one in which the backscattered channel is modulated with a low data rate signal, perhaps a single tone, to provide an Uplink acknowledgment signal that can be detected at great distances.

We now use and extend the above discussion so that several Modes of operation are present, where the different Modes are characterized by different uplink data rates. The first Mode to be discussed here is the "Interrogation Mode." The Interrogation Mode begins with the Interrogator transmitting an Interrogation Signal to the Tag. The Tag receives this Interrogation Signal, decodes it, and determines what actions to take based upon the decoded Interrogation Signal. In a "standard" Interrogation, the Tag would be requested to transmit a particular set of data (called here the Mandatory Data) back to the Interrogator, using the MBS technique discussed above. Each Tag in the reading field of the Interrogator that receives the "standard" Interrogation responds with its Mandatory Data, using a protocol discussed below. The Interrogator also transmits, as part of the "standard" Interrogation Signal, data intended for each and all Tags. Examples of such data include time of day, framing and other synchronization information, etc.

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Beyond the "standard" Interrogation, other types of Interrogations are possible as well. For example, the Interrogator, after identifying a specific Tag using the Interrogation Mode, could transmit additional data to that Tag to be stored in the Tag's memory. The Interrogator could also request the Tag transmit other data, stored in the Tag's memory, back to the Interrogator. These additional data communications could be performed at the same data rate used in the "standard" Interrogation. Thus, the Interrogation Mode is used to: transmit commands and data to each and every Tag, identify a specific Tag in the reading field, and also used to communicate in a bi-directional manner with that specific Tag. In the Interrogation Mode, the data rate required in the Downlink is typically not large, since the Interrogation Signal only must contain enough bits to request all Tags in the reading field to respond. Even when significant amounts of Downlink data are transmitted, in many applications this process does not take place frequently and the Downlink data rate is not critical. In the Uplink, the data rate is typically much larger than the Downlink data rate, as the Mandatory Data must frequently be transmitted in the Uplink in a time critical manner. Therefore, in the Interrogation Mode, we have an asymmetry in required data rates in the sense that the Downlink data rate is smaller than the Uplink data rate.

For the second, or Location Mode, the Interrogator transmits an Interrogation Signal to the Tag containing the address of a specific Tag to which this Interrogation Request is directed. In this Mode, the Tag is not requested to respond with the Mandatory Data discussed above. Instead, at least in some embodiments, the requested response is a simple acknowledgment. One embodiment of a simple acknowledgment is a constant-tone signal. Using the narrowband techniques discussed above, a constant-tone signal can be received by the Interrogator at a range far beyond the range of the Interrogation Mode. Therefore, in the Location Mode, we have an asymmetric communications path which has greater data rate in the Downlink than in the Uplink.

We now discuss methods to determine the location of a specific Tag (105). Let us assume that the system currently has no information as to the location of this Tag. Then, an Interrogation Signal is transmitted by all Interrogators, and all Interrogators listen for a response. In one embodiment, each Interrogator can determine the signal strength of the received signal (if any), and those signal strengths can be reported to a central control element. The determination of location, based upon this data, can be done in several ways. The most obvious way is for the control element to determine which Interrogator received the strongest signal strength. Then, the location of the Tag is equal to the location of that Interrogator, to

an accuracy of the effective range of that Interrogator. A more complex method could be implemented if more than one Interrogator received a return signal. Then, given a knowledge of the spatial position of each Interrogator, a refinement on the above positioning could be achieved. For example, if two Interrogators received a return signal, of equal signal strengths, then the Tag's position could be estimated at half way between those two Interrogations. If three Interrogators received a return signal, then a "triangulation" could be performed. It should be apparent that these methods will perform better if there are line-of-sight paths between the Interrogators and the Tag; if the RF communications paths rely on reflections, distorted location results could be obtained. However, it is likely that locations can be determined to an accuracy of the effective range of an Interrogator. Based upon which Interrogator receives the simple acknowledgment, a Location capability can be implemented.

For the third, or Messaging Mode, the Interrogation Signal not only contains the address of a Tag or Tags, but it also may contain data intended for that Tag or Tags. The Tag or Tags whose address matches the Tag address in the Interrogation Signal could be requested to store that data in the Tag's memory, or perform some other function with that data. There are several possible responses to an Interrogation Signal for the Messaging Mode. If the command within the Interrogation Signal requests the Tag to simply store data, then an acknowledgment to indicate successful receipt of the message could be a few bits or even a single bit of information. A single bit of information could be implemented as a constant tone acknowledgment, as mentioned above. Alternatively, if the command within the Interrogation Signal requests the Tag to make a decision, or to transmit other data back to the Interrogator, then the response would be a message consisting of more than a few bits of information. Therefore, in the Messaging Mode, we again have an asymmetric communications path which has greater data rate in the Downlink than in the Uplink.

We observe that the data-rate asymmetry found in the Location and Messaging Modes is similar to the data-rate asymmetry found in a two-way paging system. Paging transmitters (comparable to the Interrogators discussed here) have much greater transmit power than is available in a two-way paging device worn by an individual (the paging device is comparable to the Tags discussed here). Therefore, data rates in two-way paging systems are frequently asymmetric, with greater Downlink data rate than Uplink data rate. The Location and Messaging Modes of the in-building MBS system disclosed here are similar to a two-way paging system, both in technical characteristics and in applications that are supportable.

It is also possible for a transaction that began in one of the above Modes to transition into another Mode of operation. The following is an illustration of the capabilities of the system. Let us assume we wish to communicate with a Tag. A Messaging Mode Interrogation Signal is transmitted from the Interrogator to the Tag, sending data to the Tag, and requesting the Tag to respond with a simple acknowledgment, which is received by the Interrogator. Let us further assume that, based upon the simple acknowledgment received by the Interrogator, the Interrogator wishes to request that additional data, perhaps stored in the Tag's memory, be transmitted back to the Interrogator. In one embodiment, the Interrogator determines the signal strength of the simple acknowledgment signal. If the signal strength is below a certain threshold, then the Uplink data rate is limited to that data rate normally used in the Uplink for the Messaging Mode. If the signal strength is above a certain threshold, then the radio communications path between the Interrogator and this Tag can support communications at the data rate normally used in the Uplink for the Interrogation Mode. If the signal strength is below the threshold, then either data communications can continue, but using the (lower) Uplink data rate of the Messaging Mode, or a messaging could be transmitted to the Tag requesting that the Tag be brought into close proximity to an Interrogator. How that request is received by a human being is described in the above-cited Shober-Protocol application. If the signal strength is above the threshold, then data communications can continue; but using the Interrogation Mode, as discussed above. It should be obvious that, while the above example shows how the Uplink communications could take place at either one of two possible Uplink data rates, it would be possible to extend the above concept to support more than two Uplink data rates.

We now discuss how the three Modes of operation discussed above can coexist in the same system and be operational at the same time. We begin with the realization that these Modes of operation, based upon the required data rates, support different ranges from the Interrogator to the Tag. For example, the Interrogation Mode involves significant data transmission over (relatively) short time periods, such as when an individual walks by an Interrogator. The required data rate is further increased, since there can be several individuals in the reading field at one time. Thus, a protocol (such as Aloha or Slotted Aloha) is required to allow those multiple Tags to respond with their Interrogation data without mutually interfering, thus increasing required data rate. Examples of data rate for communication from the Tag to the Interrogator for the Interrogation Mode range from 50 kbps - 300 kbps. We also note that, in the absence of other factors, range and data rate trade off against each other.

In summary, we have two different "asymmetries" in data rates; greater Uplink than Downlink data rate for the Interrogation Mode, and greater Downlink than Uplink data rate for the Location and Messaging Modes. Thus, the effective range for the Interrogation Mode is smaller than that of the Location or Messaging Modes, because the Uplink data rate requirement is greater in the Interrogation Mode. In the "Narrowband Operation" section above, we disclose how to achieve significant range extension. In that discussion, a Downlink data rate of a few kilobits per second, and an Uplink data rate of a few bits per second, give roughly comparable range. This capability corresponds to the requirements of the Location and Messaging Modes discussed above. For the Interrogation Mode, a Downlink data rate of a few kilobits per second is also adequate, since relatively few bits of data in the Downlink are required, and Uplink data rates are from 50 kbps - 300 kbps. The Downlink range is the same for all three Modes. The Uplink range for the Location and Messaging Modes is roughly the same as the Downlink range. The Uplink range for the Interrogation Mode is much smaller.

Here, we disclose how all three of these modes of operation, Interrogation, Location, and Messaging, can be implemented in and supported by a single, useful, inexpensive end-user device. We call this device a Personal Pager IDentifier (PPID). A block diagram of the PPID is shown in FIG. 4.

PPID Description

The Antenna (401) can be a patch or a loop antenna. The patch antenna has certain advantages for a PPID. The patch antenna can be plated onto the substrate of the PPID device, and the back of the substrate can be a "ground plane" for the patch antenna. This general design will create a antenna "pattern" that is preferentially directed "outwards" - i.e., in directions away from the ground plane. Because of the relatively small size of the PPID - similar in size to an employee badge - and for radio frequency propagation reasons - it is common for RF signals at microwave frequencies to be used. These frequencies, such as 2450 MHz - support very small patch antenna designs (roughly 0.5 inch square).

Therefore, a PPID device, worn as an employee badge, with the patch antenna facing outwards, will optimize radio communications in front of the employee. In this way, when the employee moves towards a doorway with an Interrogator, the Interrogator can establish radio contact with the PPID as soon as possible. As discussed above, the Antenna (401) and Detector Modulator (402) designs are important. The Amplifier (403) design is also important. For the PPID to provide the required Downlink range for the Location and Messaging Modes, the

Amplifier (403) must be able to boost a very weak demodulated AM signal to CMOS levels, operate over a very great dynamic range (because the PPID could be either very close to or very far away from an Interrogator), and draw very little current. Integrated over time, the Amplifier (403) should draw at most a few microamps of current.

The Processor (404) can be a conventional 4 or 8 bit microprocessor as discussed above. The Processor (404) must have a "sleep" mode, in which the current consumption is less than a microamp, and also have an "active" current consumption of far under a milliamp. The role of the Processor (404) is to be the "brain" of the PPID, decoding the Downlink Signals, determining what type of Uplink response is required, etc. The Processor (404) could be clocked from a separate Crystal (430), or from an oscillator contained within the Processor (404).

Data Storage (420) is also present in the PPID. In one embodiment, the Data Storage (420) could be located in the microprocessor, as either volatile or non-volatile storage. In an another embodiment, the Data Storage (420) could be located in another integrated circuit, such as a EEPROM. The amount of storage supported in a PPID could range from as little as a few bytes of storage up to tens of thousands of bytes of storage.

The Subcarrier Modulator (405) functions as disclosed in the above-cited Shober-Protocol application, which is hereby incorporated by reference. It is capable of modulating an information signal, of varying data rates, onto a Subcarrier signal which is generated by a Subcarrier Source (406). The Subcarrier Source (406) could be an inexpensive crystal, or it could be a frequency source derived from the main Crystal (430) used to clock the Processor (404).

To display information transmitted to the PPID using the Interrogation Mode or the Messaging Mode, the PPID has a Display (408). To allow the person carrying the PPID to respond to messages, Pushbuttons (407) are also present. A PPID could have one or more than one Pushbuttons (407).

We now observe the similarities between the PPID device as shown in FIG. 4 and other devices on the market today. First, consider an inexpensive "four-function" calculator. Such a calculator consists of a power supply, which could be either a battery or a solar cell; a processor, typically a 4 or 8 bit microprocessor (or ASIC with a microprocessor core); a display, which is typically a glass or plastic liquid crystal display; and pushbuttons to allow numerical inputs and functions to be entered. We note that such a four-function calculator is sufficiently inexpensive today that in many cases these devices are given away as presents, souvenirs, etc.

Next, consider an inexpensive quartz watch. The watch also has a battery, a processor (again, commonly a 4 or 8 bit microprocessor or an ASIC with a microprocessor core), a display, and pushbuttons to allow the correct date and time to be set. Again, such devices are commonly priced below $10 and are sometimes given away.

In summary, we see that inexpensive devices such as a calculator or a quartz wrist watch already possess many of the elements of a PPID as shown in FIG. 4. The additional components, shown in FIG. 4, are relatively inexpensive; the Antenna (401) is plated onto a substrate and therefore only costs substrate area, the Detector Modulator (402) is a single diode that in volume can be purchased for under $0.10, the Amplifier (403) can be realized at a cost of under $0.50, the Subcarrier Modulator (405) can be implemented in a few gates costing a few cents, and the Subcarrier Source (406) can be an inexpensive crystal costing as little as $0.15 (depending on the frequency of the crystal). Thus, for a total additional cost of as little as $0.75, a calculator or a quartz watch could have about the same functionality as a PPID.

We now consider the similarities between a Pager and a PPID. The pager already has an antenna (although likely tuned to the wrong frequency), battery, processor, display, and pushbuttons. However, Pagers are more expensive than PPIDs because their radio circuitry, to obtain the range required of a Paging system, is expensive. A two-way Pager -- i.e., a device capable of not only receiving a page but also transmitting a response -- will be even more expensive.

Therefore, the invention disclosed here is not based on taking relatively expensive technology -- like contained within a Pager -- and making it less expensive. This invention is based on starting with inexpensive technology -- such as that present in a calculator or watch -- and adding other inexpensive elements such that the functionality is vastly increased.

One item to mention is that the PPID may require a larger display than that normally available on a calculator or a watch. However, this does not diminish the fact that great additional functionality could be added to what is essentially a very low-cost device, by using modulated backscattered radio technology.

PPID Physical Design

An illustration of a possible PPID design is shown in FIG. 5. The PPID has overall dimensions similar to that of an employee identification badge. The thickness of the PPID depends on the manufacturing techniques used, the type of power supply used, etc. A typical thickness with would likely be about 1/16 inch;

however the technology of "thin electronics" is rapidly advancing.

The Display (501) could be at the top of the PPID. Display (501) is shown with two lines of display; assuming each line presented 10-20 characters, then the total amount of display would be 20-40 characters. This amount of display should be sufficient for most applications. The Employee Photo (502) could be placed below the display; under the photo would be an ideal place for the Antenna (503), which is plated onto the substrate, to be located. To the left of the employee Photo (502) could be the Company Logo (504). Below the Employee Photo (502) and the Company Logo (504) could be the Employee Name (505). Below the Employee Name (505) could be Pushbuttons (506). The Coil (507) could be located beneath the Company Logo (504).

In an alternate embodiment (FIG. 6), the Employee Photo (601) Company Logo (602) are on top, the Employee Name (603) is below, with the Display (604) below the Employee Name (603). The Pushbuttons (605) are at the bottom. As above, the Antenna (606) could be located immediately behind the Employee Photo (601). Above, we discussed the similarity between a four- function calculator and a PPID. It would be straightforward, and add relatively little cost, to add enough Pushbuttons (605) to the PPID so that it will function as a four-function calculator in addition to functioning as a PPID.

Power Management

An important design parameter for the PPID will be the battery lifetime of the PPID. There are several approaches to the problem of battery life. One approach is for the PPID to provide for a replaceable Battery (409). In this manner the PPID can have a useful lifetime not limited by battery considerations. The disadvantage of having a replaceable Battery (409) is that the PPID may not be water resistant; however watch manufacturers have developed techniques to made water resistant or waterproof watches even with replaceable batteries. Another approach is for the PPID to have a Solar Cell (410) as a power source. This approach has the following limitation: Since PPID operation in low light conditions is just as important as in bright light conditions, the Solar Cell (410) would have to be complemented by an Energy Storage Device (411), which would add cost. The combination of a Solar Cell (410) and an Energy Storage Device (411) could be more expensive than the cost of a replaceable battery.

Another approach is for an Energy Storage Device (411) to be combined with a device to re-charge the Energy Storage Device (411); such a device is a Coil (412). Energy could be inductively coupled and transferred to the Energy Storage

Device (411) through the Coil (412) if the PPID were placed in close proximity to a recharging device with a similar coil operating at a frequency to which the Coil (412) was sensitive.

Another approach, of course, is for a Battery (409) to be built into the PPID at manufacture time and the entire device permanently sealed. This has advantages since the concerns about water damage are not present.

Despite the above alternatives to the problem of providing energy to the PPID, and regardless of which alternative is selected, the PPID must be designed with energy conservation in mind. It is for that reason that concern was discussed above about the electrical current draw of the individual components of the PPID. A final point to mention is that the PPID would be operated in a fashion where the device is not fully functioning at every moment of time. The Processor (404) can have the ability to "go to sleep"; i.e., to enter a state where active processing is not taking place and where the current drain of the processor is quite low. The Processor (404) can also direct the Amplifier (403) to "go to sleep", or to enter a state where Downlink signals cannot be processed and the current drain is also low. Finally, the Processor (404) could decide, if there is no data to be displayed; e.g. if the last message received has been acknowledged, the Processor can halt the operation of the Display (408). Of course, the PPID cannot remain asleep indefinitely, as then it will fail to receive messages and other communications.

There are at least two techniques that can be used to determine when the PPID should be asleep and when it should be awake. First, the Processor (404) could be programmed to wake up at routine intervals (many microprocessors have a watchdog timer for such a purpose). This technique is used by Pagers to allow the device to sleep most of the time. The critical element in this technique is the determination of the length of time the PPID sleeps. To determine this length of time, several factors must be considered. First, the PPID must respond to Interrogation Mode requests as discussed above. Then, the PPID must be awake frequently enough so that, when the PPID enters the reading field of an Interrogator operating in the Interrogation Mode, the PPID can detect the Interrogation Mode signals and properly respond. For example, given an Interrogation Mode range of 30 feet, and a walking speed of 3 feet per second, the PPID must be awake at the very least every 10 seconds, and more likely every 1-3 seconds, to be assured that the Interrogation Mode signals are not missed. Second, the PPID must have a large enough ratio of "total time" divided by "awake time" in order to reduce the current drain enough so that the PPID can be powered by a reasonably small battery, such as a coin cell. This ratio should ideallv be as much as 10:1. Third, the PPID must also

not be asleep when Location Mode or Messaging Mode messages are transmitted. It can be assured that the PPID is awake when these messages arrive by designing the overall PPID protocol in conjunction with the frequency that the PPID goes asleep. An example of such a protocol design is shown below.

The second technique to assure that the PPID is asleep most of the time is to add an additional element -- an RF Detector (701) -- to the PPID (FIG. 7). The purpose of the RF Detector is to send a signal to the Processor (404) to awaken it whenever the PPID is in the presence of an RF field. If the PPID is not in an RF field; e.g., the PPID has been taken out of the building for the evening, then the PPID would not awaken until the PPID was re-introduced into the building. This would clearly lead to considerable savings in current drain. However, this technique has drawbacks as well. It would be straightforward and relatively inexpensive to design an RF Detector (701) capable of detecting a strong RF field. However, a major advantage of the PPID is that it is capable of detecting weak RF signals, such as those Downlink signals from the Location and/or Messaging modes. A device capable of detecting the presence of a weak RF signal would be essentially as complex as the combination of the Detector (402) diode and the Amplifier (403). This is equivalent to saying that the Detector (402) diode and Amplifier (403) are always awake, but the Processor (404) is asleep until RF signals are heard. This technique may not yield appreciable savings beyond what is possible with the "regular sleep time" technique outlined above. An additional problem with this approach is the following. When the PPID device is brought into a building, since the entire building is covered by at least one Interrogator, the PPID would continually be in an RF field, and thus continually awake. To circumvent this problem would involve a more complex RF Detector (402), which causes the additional problems outlined above. However, for applications in which the PPID is in an RF field only a small percentage of the time, this technique may be preferred.

Authorization and Security

There are at least three techniques used for authorization and security in high-security environments. One technique is to check "something you have in your possession", such as an employee badge. Another technique is to check "something you know", which is typically implemented as a password, PIN, etc. Another technique is "something about you", for example a picture, a voiceprint, a fingerprint, a retinal scan, etc.; this data is sometimes called "biometric data."

All three of these techniques can be applied to the use of the PPID. The PPID (400), itself, is the "something you have in your possession." Since the PPID has Pushbuttons (such as 605), it would be possible for the employee to be required to enter a PIN into the PPID in order to, for example, authorize initial building entry, or authorize entry into a particularly high security area. In an alternate embodiment, the employee could use the PPID in the Interrogation Mode to be identified, and then the employee could be required to type in a PIN on a keyboard, for example, located next to the doorway. Thus, the PIN is the "something you know." Finally, the PPID (400) could store the "something about you." With the cost of memory decreasing, it would be possible to have substantial amounts of Data Storage (420) on the PPID (400); for example, 32 kbytes of EEPROM are possible in a single IC. A compressed voiceprint or picture or other such data could be stored in less than 8 kbytes. The PPID (400) would first be identified using the Interrogation Mode discussed above; then the Messaging Mode could be used to request the data be transmitted to the Interrogator. This data could be then compared, using either computer techniques or by a human being, with data taken from the employee; for example from a video camera, microphone, scanning station, etc. This would facilitate an entryway with full security, but without the presence of an on-duty security person dedicated to this entryway. The security person could be located in a central security facility and support multiple entryways.

One additional element of security involves the personal security of the employee in possession of the PPID (400). Let us assume that for some reason this employee encounters an emergency condition. It would be possible for the employee to enter a certain sequence of data in the Pushbuttons (407) that indicate an emergency condition. Depending on the sequence of data entered, additional data concerning the nature of the emergency could also be entered. Upon receipt of the next Downlink Signal, regardless of which Mode, the PPID could transmit a message containing data indicating the fact of the emergency and also, optionally, the nature of the emergency. Thus, the Applications Processor (101) could be alerted, and the proper authorities could be alerted using the Communications Link (130).

PPID Operational Capabilities

We now outline how the PPID (400) could operate. As the employee enters the building, an Interrogator (103) monitoring the entrance to the building establishes radio communications with the PPID through the use of the Interrogation Mode, and optionally transmits data to the PPID such as the time and/or the date so

that the PPID is time-synchronized with the radio communications system. The Interrogator then reports to the Applications Processor (101) the fact that a specific PPID was interrogated, and an interrogation time stamp. Other Interrogators throughout the building regularly transmit Interrogation Mode Signals; when the PPID is in range and receives such a signal, it transmits an uplink signal containing the mandatory data as outlined above. Any other Interrogator (103) that successfully communicates with the PPID through the Interrogation Mode communicates this fact, along with the interrogation time stamp, back to the Applications Processor (101). Therefore, a time history of the location of a specific PPID is built up in a database, called the Location Database (110), in the Applications Processor. Since the effective range of the Interrogation Mode is less than that of the Location and Messaging Modes, the database history of a specific PPID will not be continuous, in the sense that there will be periods of time in which the PPID is not in range of the Interrogation Mode. Therefore, the Interrogation Mode communications have several results. First, the Interrogation Mode is used to authorize initial entrance to the building. Second, the Interrogation Mode could also be used to authorize entrance to other doorways in the building, such as secure areas, etc.; the Interrogation Mode could also be used to authorize entrance to the employee's office door. Third, the use of the Interrogation Mode by Interrogators throughout the building allows a time history, albeit not continuous, of the approximate location of a specific PPID.

Let us assume that the Location of a specific PPID (400) is desired. A request for such a location is transmitted to the Applications Processor (101) over a Communications Link (130), which could be connected to the LAN, as shown in FIG. 1, or alternately could be connected directly to the Applications Processor (101). The Applications Processor (101) first checks the Location Database (110) to determine whether the location of the PPID (400) was recently obtained. If no recent determination of location was made, then the Applications Processor (101) determines that the location of this PPID is unknown, and a Location Mode Signal is transmitted by all Interrogators, requesting the PPID to respond. If the location of the PPID was recently determined, then in one embodiment only Interrogators (103) in the vicinity of this previously determined position could transmit a Location Mode Signal addressed to this specific PPID (400). Then, the Interrogators (103) transmit to the Applications Processor (101) the results of the Location Mode Signal; whether a response signal was detected, and if so, the signal strength of that signal. The Applications Processor (101) can then determine the approximate location of the PPID and return that information to the requester over the Communications Link

(130).

Let us assume that a message is desired to be transmitted to a PPID (400). The Applications Processor (101) receives such a request over the Communications Link (130), and stores the message to be transmitted to the appropriate PPID in the Messaging Database (120). The Applications Processor then checks the Location Database (110) to determine whether the location of the PPID (400) was recently obtained. If no recent determination of location was made, then the Applications Processor (101) determines that the location of this PPID is unknown, and a Messaging Mode Signal is transmitted by all Interrogators. If the location of the PPID (400) was recently determined, then in one embodiment only Interrogators (103) in the vicinity of this previously determined position could transmit a Messaging Mode Signal addressed to this specific PPID (400). The PPID (400) receives the Messaging Mode Signal, and responds with an acknowledgment message, using MBS, to the Interrogator. Thus, the "session" in this example consists only of the Downlink Messaging Mode Signal and the Uplink acknowledgment message. The Interrogator that receives the acknowledgment message reports this to the Application Processor (101), which marks this message in the Messaging Database (120) as having been delivered.

Let us assume that data is desired to be received from a specific PPID (400). The Applications Processor (101) receives such a request over the Communications Link (130), and stores the request in the Messaging Database (120). The Applications Processor then checks the Location Database (110) to determine whether the location of the PPID (400) was recently obtained. If no recent determination of location was made, then the Applications Processor (101) determines that the location of this PPID is unknown, and a Messaging Mode Signal is transmitted by all Interrogators. If the location of the PPID (400) was recently determined, then in one embodiment only Interrogators (103) in the vicinity of this previously determined position could transmit a Messaging Mode Signal addressed to this specific PPID (400). The PPID (400) receives the Messaging Mode Signal, and responds with an acknowledgment message, which acknowledges receipt of the Messaging Mode Signal. This transaction establishes the "session". The Interrogator (103) measures the signal strength of the acknowledgment message, and based on this signal strength, determines what Uplink data rate can be supported to this Tag. Communications could be supported at a low data rate (for optimum range), or at a high data rate (for optimum data rate), depending on Uplink signal strength. The Interrogator (103) transmits another Messaging Mode Signal to the PPID (400), instructing the PPID which Uplink data rate to use in transmitting the

required data. After this data is transmitted, this marks the end of the "session". After the required data has been received by the Interrogator (103), the Interrogator transmits the data to the Application Processor (101), which then transmits the data over the Communications Link (130). In an alternative embodiment, the Applications Processor (101) stores the data in the Messaging Database (120) in the event the data is required later or in the event that the transmission over the Communications Link (130) fails.

Let us assume that data is desired to be transmitted to, and also received from, a specific PPID (400). Given the above discussion, it should be clear how both of these functions could be incorporated into the same "session" between an Interrogator and a Tag.

Based on the Messaging Mode capability, the PPID (400) could be transmitted data, not for storage in the Data Storage (420) module, but for display on the Display (408). For example, the Application Processor (101) could be requested, through communications over the Communications Link (130), to transmit a message to a particular PPID (400) that the employee has received an urgent telephone call or an urgent electronic mail message. Notification of the receipt of such a call or electronic mail message could be displayed on the Display (408). It may be helpful for the PPID (400) to alert the employee that a new message is being displayed on the Display (408). The PPID (400) could have an Alert Device (413) built in, which could be a buzzer (or other such sound maker) or vibrator.

An extension of the above Messaging Mode scenario involves sending a message to a specific PPID (400), having that message displayed on the Display (408), and requesting the employee to enter an acknowledgment into the PPID (400) indicating that the employee saw the message. The acknowledgment could, e.g., be entered by pressing a specific Pushbutton or Pushbuttons (407). This would allow the Applications Processor (101) to be certain that a critical message was received.

In a high security environment, additional precautions can be taken. One technique is as follows. The Interrogation Mode is used to identify the PPID whose employee is requesting access to a specific entryway. As discussed above, the Messaging Mode is then used to request that data be transmitted back to the Interrogator. If the required data is a PIN, then the employee must enter the PIN into the PPID's (400) Pushbuttons (407); this PIN is then transmitted back to the Interrogator. If security of the PIN is an issue, that communication could easily be encrypted. In the event that "something about you" was stored in the Data Storage (420) of the PPID (400), the Messaging Mode could be used to request that data be transmitted from the PPID to the Interrogator (103), and then transmitted to the

Applications Processor (101).

There are times in which the employee will not want to be located. The PPID (400) could be instructed, perhaps by the employee entering specific data into the Pushbuttons (407), to only respond to certain of the Modes of operation, or alternately to not respond to any of the Modes of operation. For example, the employee could use the PPID (400) to gain access to the building, but then disable the PPID (400) in this manner.

In a security environment, however, employees surrender some elements of personal privacy. If the employee disables the PPID (400), then the employee forfeits the ability to enter other controlled access entryways. Further, let us assume that we wish to monitor an entryway to assure ourselves that a person does not move past that spot without a valid PPID (400) being read. It is possible to incorporate a motion detection system to the RFID system discussed here. In addition, it is possible to incorporate motion detection capability into the Interrogator (103) described here, with the addition of a Motion Detector (220), which detects Doppler shifted signals in the audio frequency range. Therefore, an Interrogator (103) could be configured to return an alarm to the Applications Processor (101) in the event that motion was detected but no PPID (400) was read.

Finally, in some very high security applications, it may be required for the Applications Processor (101) to "override" the ability of the employee to disable the PPID (400). For example, assume the three Modes of operation have two command types; "System" level commands and "User" level commands. This is similar to certain commands on a computer system requiring different levels of authorization. The disabling of the PPID (400) by use of the Pushbuttons (407) would not deactivate the PPID fully; but rather, could set the PPID in a mode where it only responded to "System" level commands and not to "User" level commands. This distinction could be very helpful in a building environment in which certain parts of the building were at a much higher level of security than others; the "User" level commands could be used in areas of lower level of security, and the "System" level commands could be used in areas of high level of security.

Among the methods of powering the PPID discussed above, two methods were an Energy Storage Device (411) and a Coil (412). These methods could be used together as follows. Assume that a Docking Station (800, FIG. 8) was developed. The PPID (400) would be placed on top of the Docking Station (800) when the Energy Storage Device (411) required charging. The Coil (412) of the PPID (400) would be oriented so that it was directly on top of a similar Coil (801) in the Docking Station (800). Thus, the Energy Storage Device (411) could be re-

charged. Another helpful use of the Coil (412) would be to power the PPID (400) in the event that the Energy Storage Device (411), the Battery (409), or whatever method of powering was used failed to operate. This would allow the data in the PPID (400) to be recovered even in the event of such failure.

What has been described is merely illustrative of the application of the principles of the present invention. Other arrangements and methods can be implemented by those skilled in the art without departing from the spirit and scope of the present invention.

FIG. 1

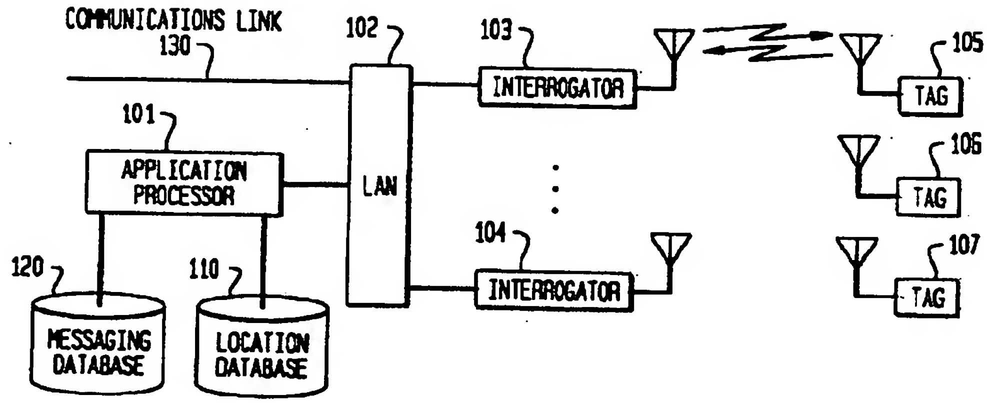

COMMUNICATIONS LINK
130
102
103
INTERROGATOR
105
TAG
101
APPLICATION PROCESSOR
LAN
106
TAG
104
INTERROGATOR
107
TAG
120
110
MESSAGING DATABASE
LOCATION DATABASE

FIG. 2

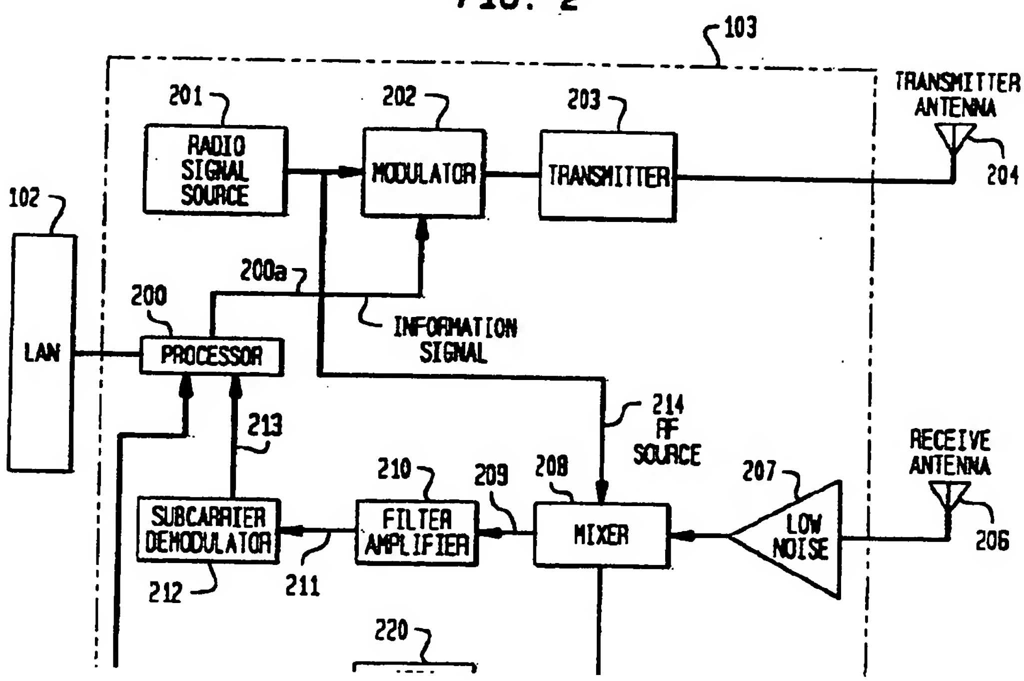

103
201
202
203
TRANSMITTER ANTENNA
RADIO SIGNAL SOURCE
MODULATOR
TRANSMITTER
204
102
200a
200
LAN
PROCESSOR
INFORMATION SIGNAL
214
RF SOURCE
213
210
209
208
207
RECEIVE ANTENNA
SUBCARRIER DEMODULATOR
FILTER AMPLIFIER
MIXER
LOW NOISE
206
212
211
220

FIG. 3

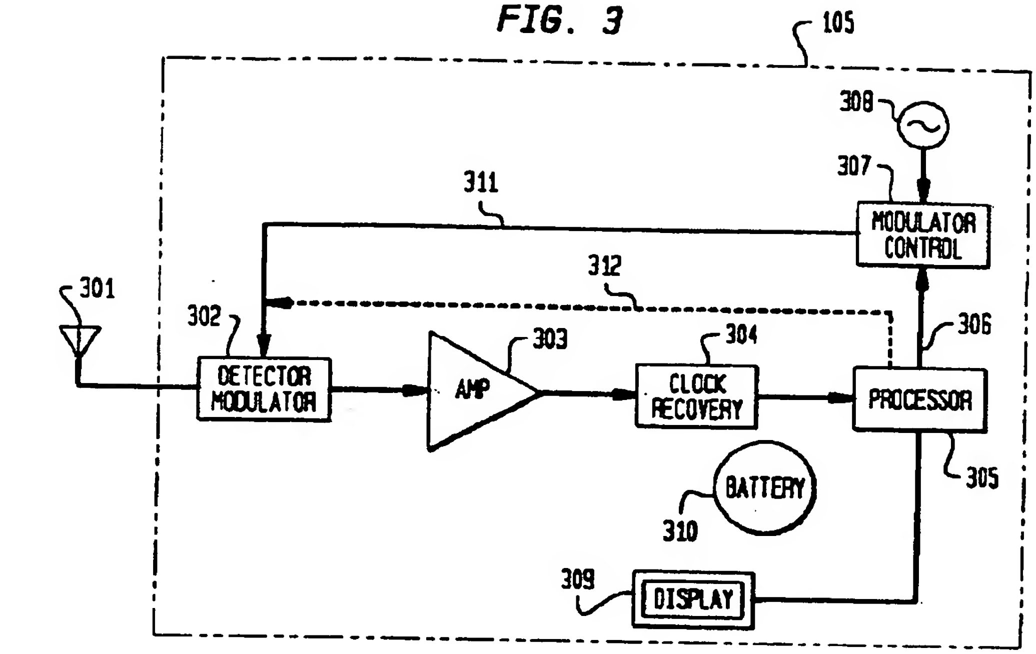

105
308
307
MODULATOR CONTROL
311
312
301
302
DETECTOR MODULATOR
AMP
303
CLOCK RECOVERY
304
PROCESSOR
306
305
BATTERY
310
309
DISPLAY

FIG. 4

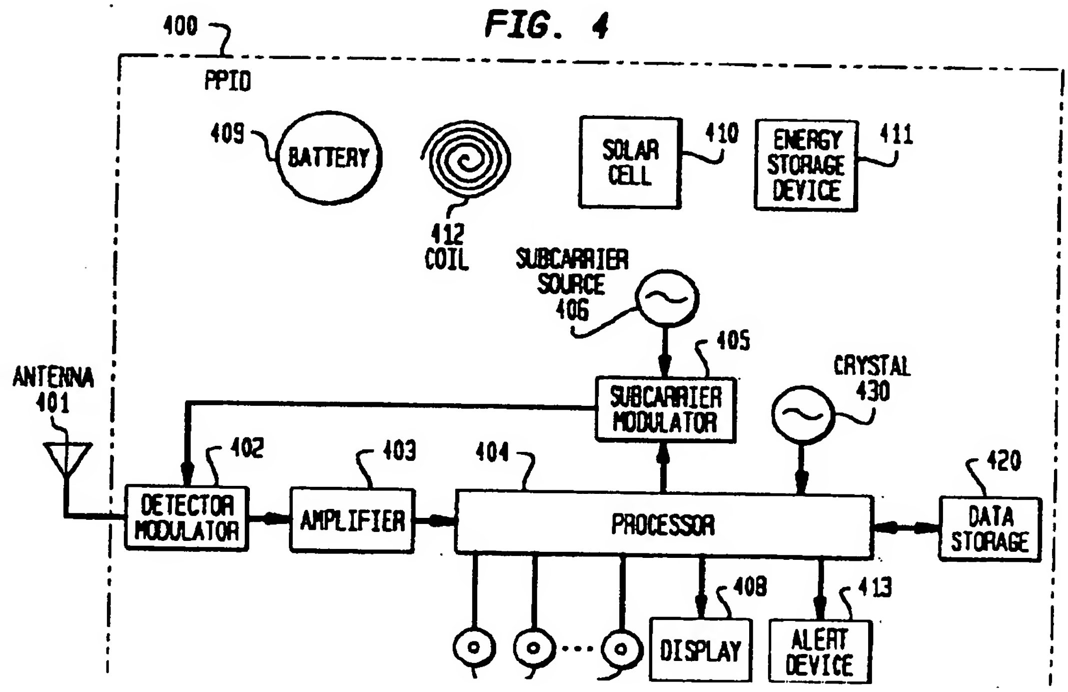

400
PPID
409
BATTERY
412
COIL
SOLAR CELL
410
ENERGY STORAGE DEVICE
411
SUBCARRIER SOURCE
406
405
SUBCARRIER MODULATOR
CRYSTAL
430
ANTENNA
401
402
DETECTOR MODULATOR
403
AMPLIFIER
404
PROCESSOR
420
DATA STORAGE
408
DISPLAY
413
ALERT DEVICE

FIG. 5

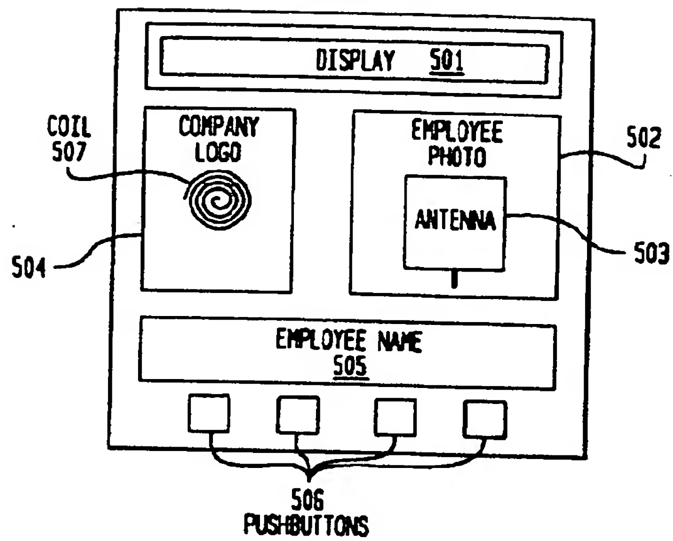
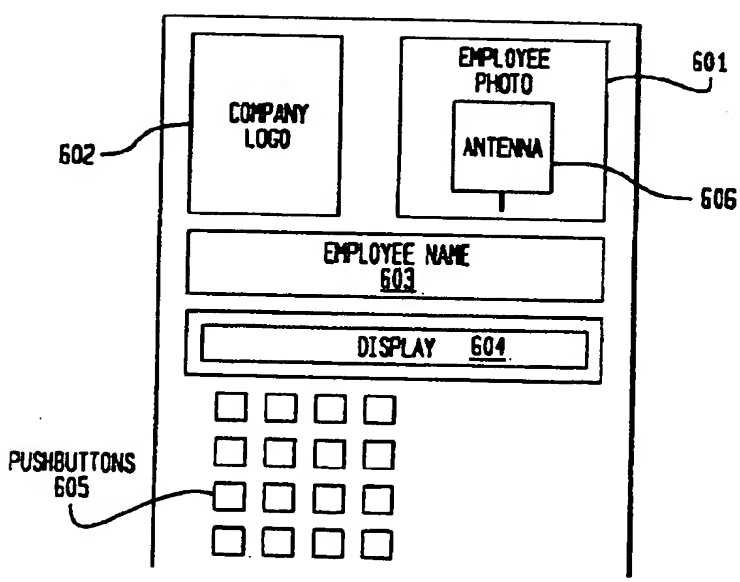

DISPLAY 501
COMPANY LOGO
EMPLOYEE PHOTO
ANTENNA
COIL 507
502
503
504
EMPLOYEE NAME 505
506 PUSHBUTTONS

FIG. 6


EMPLOYEE PHOTO
601
COMPANY LOGO
602
ANTENNA
606
EMPLOYEE NAME 603
DISPLAY 604
PUSHBUTTONS 605

7/7

FIG. 7

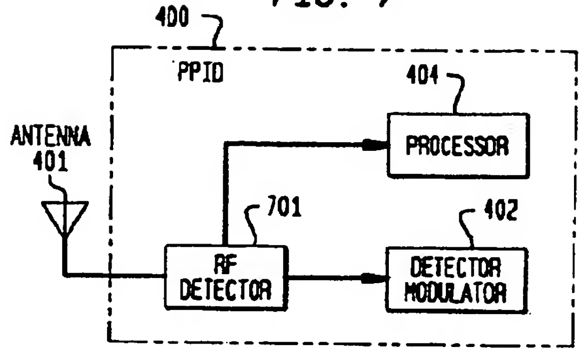
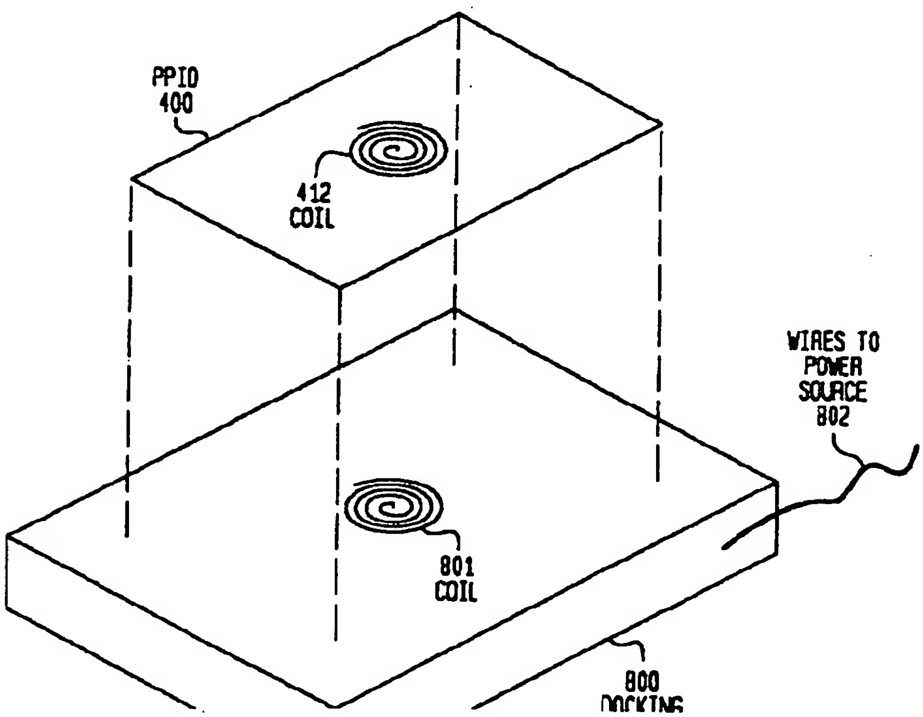


FIG. 8



1 Abstract

In accordance with the present invention, a radio personal communications device is disclosed, which is capable to receiving modulated radio signals, and capable of transmitting modulated radio signals using modulated backscatter technology. This device can operate in an Interrogation Mode, in which a set of mandatory data is transmitted from the device; in a Location Mode, in which the approximate location of the device can be determined, and in a Messaging Mode, in which data can be transmitted to and received from the device. The device is capable of transmitting information, using modulated backscatter, at more than one data rate. The device contains a display to display some or all of the data transmitted to the device. Alternate embodiments of the invention allow the device to also support pushbuttons to allow data to be input to the device. Alternate embodiments support a variety of powering mechanisms for the device, including batteries, charge storage devices, solar cells, a coil or other energy transfer device, etc. A recharging station is also disclosed in the event the power supply of the device requires recharging.

2 Representative Drawing

Figure 1

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H04B 1/59		H04B 1/59	
5/02		5/02	

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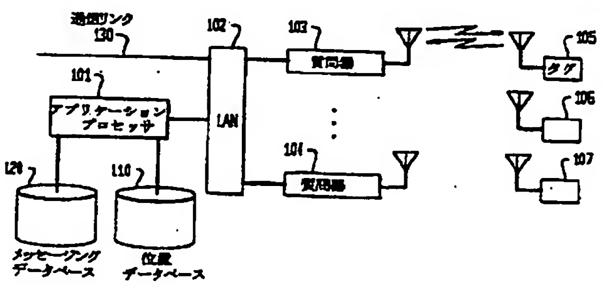
最終頁に続く

(54)【発明の名称】　通信システム

(57)【要約】

【課題】　変調バックスキャッタ技術を用いて、セキュリティを改善し、低コストのビル内又はキャンパスにおける位置決定及び通信サービスを提供する。

【解決手段】本無線通信装置は、変調無線信号を受信し、変調馬技術を用いて変調無線信号を送信することができる。本装置は変調バックスキャッタ技術を用いて1以上のデータ速度で情報を送信することができる。プッシュボタンをサポートして本装置へデータを入力することもできる。電池、電荷蓄積装置、太陽電池、コイル等のエネルギー変換装置によって本装置に電源を供給できる。電源が充電を必要なときには充電ステーションを用いる。



【特許請求の範囲】

【請求項１】　（Ａ）第１情報信号の回復を行うことができる、受信変調無線信号の変調器と、
（Ｂ）前記第１情報信号に応じて、少なくとも２つの代替動作（動作Ａ及び動作Ｂとする）の選択された１つを指示する出力を供給する第１判断要素と、
（Ｃ）前記第１情報信号の少なくとも一部を表示する表示装置と、
（Ｄ）前記判断要素の出力に応じて、第２情報信号を生成する信号生成装置とを有し、
前記第２情報信号は、データ速度を有し、このデータ速度は、動作Ａが指示されたときの方が動作Ｂが指示されたときよりも大きく、
（Ｅ）前記第２情報信号を用いて、受信変調無線信号の反射を変調するバックスキャッタ変調器とを有することを特徴とする通信装置。

【請求項２】　（Ｆ）サブキャリア信号の生成器と、
（Ｇ）変調されたサブキャリアを形成するために、前記サブキャリア信号を前記第２情報信号で変調する変調器とを更に有し、
前記バックスキャッタ変調器は、前記受信変調無線信号の反射を前記変調サブキャリアで変調することを特徴とする請求項１の通信装置。

【請求項３】　前記変調器は前記第１判断要素に応じ、動作Ｂに対する変調サブキャリアが前記サブキャリアの周波数で純粋な非変調トーンであるようにされることを特徴とする請求項２の通信装置。

【請求項４】　（Ｆ）プッシュボタンを更に有し、
前記信号生成装置は前記プッシュボタンに応じ、前記第２情報信号の内容の少なくとも一部が前記プッシュボタンの押下により決められることを特徴とする請求項１の通信装置。

【請求項５】　（Ｆ）プッシュボタンと、及び（Ｇ）前記第２情報信号を送信すべきかを指示する出力を供給する第２判断要素とを更に有し、
この第２判断要素は前記プッシュボタンに応じ、前記プッシュボタンの押下によって前記第２情報信号を送信すべきかが指示されることを特徴とする請求項１の通信装置。

【請求項６】　アラーム装置と、及び前記第１情報信号の内容に基づいて前記アラーム装置をアクティベートする手段とを更に有することを特徴とする請求項１の通信装置。

【請求項７】　前記第１情報信号の少なくとも一部を記憶する記憶媒体を更に有することを特徴とする請求項１の通信装置。

【請求項８】　前記通信装置内に記憶されたデータから前記第２情報信号の少なくとも一部を生成する手段を更に有することを特徴とする請求項１の通信装置。

【請求項９】　前記通信装置のホルダーに関するバイオメトリックデータの記録を更に有し、
前記信号生成装置は、前記第２情報信号におけるデータの少なくとも一部を扱うことを特徴とする請求項１の通信装置。

【請求項１０】　エネルギー転送要素と、及びこのエネルギー転送要素を通して充電可能なエネルギー記憶要素とを更に有することを特徴とする請求項１の通信装置。

【請求項１１】　前記エネルギー転送要素は、コイルからなることを特徴とする請求項１０の通信装置。

【請求項１２】　前記エネルギー転送要素は、キャパシタからなることを特徴とする請求項１０の通信装置。

【請求項１３】　太陽電池と、及び前記太陽電池から充電可能なエネルギー記憶装置とを更に有することを特徴とする請求項１の通信装置。

【請求項１４】　スリープモード及びウェークモードを有するシグナルプロセッサと、
前記スリープモードから前記プロセッサを規則的に起こして前記ウェークモードにする手段とを有することを特徴とする請求項１の通信装置。

【請求項１５】　スリープモード及びウェークモードを有するシグナルプロセッサと、
ＲＦ検出器とを有し、
前記シグナルプロセッサは、前記ＲＦ検出器に応答し、ＲＦ場の存在が検出されたときに前記プロセッサを起こして前記ウェークモードにすることを特徴とする請求項１の通信装置。

【請求項１６】　グラフィックスと、
前記グラフィックスの下に少なくとも一部が位置するアンテナとを更に有することを特徴とする請求項１の通信装置。

【請求項１７】　グラフィックスと、
前記グラフィックスの下に少なくとも一部が位置するエネルギー変換デバイスとを更に有することを特徴とする請求項１の通信装置。

【請求項１８】　前記グラフィックスは、前記通信装置のホルダーの絵であることを特徴とする請求項１６又は１７の通信装置。

【請求項１９】　前記グラフィックスは、団体のロゴであることを特徴とする請求項１６又は１７の通信装置。

【請求項２０】　数字キーボードを構成する複数のプッシュボタンと、
前記プッシュボタンにより入力されるマイクロプロセッサとを有し、
このマイクロプロセッサは、前記プッシュボタンの操作に応答して何らかの数学的演算を行い、そのような演算の結果を表示装置へと表示することができることを特徴とする請求項１の通信装置。

【請求項２１】　緊急モードを指定するプッシュボタンと、
前記プッシュボタンの操作に応答して、緊急モードが指

定された後に次の第１情報信号を受け取って緊急モードを実行する手段とを有し、
前記信号生成装置は、前記緊急モードを実行する手段に応答し、緊急モードが実行された後、緊急状態を表すデータを有する第２情報信号を生成することを特徴とする請求項１の通信装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】この発明は、無線通信システムに関し、特に、建物内、キャンパスにおける変調バックスキャッタ技術を用いた無線通信システムを用いた無線通信システムに関する。
【０００２】
【従来の技術】個人の自動識別をサポートするようにセキュリティアクセスシステムが開発されている。例えば、従業員がビルへ入ることを認証するシステムである。本明細書では、「従業員」とは本発明の実施者がサービスを提供する客体をいう。このような機能を有するものとして従業員識別バッジがある。これにより警備員がチェックして認証する。磁気キーを有するカードもある。
【０００３】機械、在庫品又は生き物を識別したりその動きをチェックする目的で、無線周波数識別（ＲＦＩＤ）システムが利用されている。ＲＦＩＤシステムは、質問器（インテロゲータ）と呼ばれる一つの無線送受信器と、タグと呼ばれる多数の安価な装置との間で通信する無線通信システムである。
【０００４】ＲＦＩＤシステムでは、変調無線信号を使用して質問器からタグへ通信し、タグは変調無線信号により応答する。質問器は、タグにメッセージを送った（ダウンリンクと呼ばれる）後に、連続波（ＣＷ）無線信号をタグに送る。それからタグは、変調バックスキャッタ（ＭＢＳ）を用いてそのＣＷを変調する。このＭＢＳでは、アンテナは、変調信号により、ＲＦ（無線周波数）放射の吸収体の状態からＲＦ放射の反射体の状態に電子的にスイッチ操作される。この変調バックスキャッタにより、タグから質問器への通信（アップリンクと呼ばれる）が可能になっている。
【０００５】従来のＭＢＳシステムは、（ａ）質問器の領域へと通過する物体を識別するため、及び（ｂ）タグ上にデータを記憶し後にそのタグからデータを取り出して、目録を管理したり他の有用なアプリケーションを行う。
【０００６】キャンパスや建物の中で用いる場合を考える。そしてまず、ＲＦＩＤ技術を「セキュリティ」に用いる場合を考える。ＲＦＩＤは今日セキュリティ業界にて建物アクセスを容易にするように用いられている。例えば、建物への入館を自動的に認証させて行ったり、特定の位置を通過した個人を記録したりする。この動作は質問モードと呼ばれる。即ち、質問器が読みとりフィールド内の全てのタグへ信号を送信し、そのタグを識別させるデータによってタグが応答することを要求する。次にタグはＭＢＳを用いて質問器へこの情報を送り返す。

【０００７】加えて、「位置決定」アプリケーションが建物等に存在する。（本明細書において、「建物」、「建物内」は建物の中ないし建物をも含むようなキャンパス環境等を意味する。）例えば、建物内の特定のタグの位置を知りたいことがある。このことは高度なセキュリティを要するような場合に求められる。建物内電話システムにおいて電話の呼をある個人が位置する場所に近い電話機へルーティングするようなアプリケーションにも用いることができる。原型のシステムとして赤外線送信器を用いる例があるが、実際に市場化されておらず、赤外線技術はとどく範囲が狭く、物体を透過する能力に欠ける。従って、赤外線送信器がシャツのポケットの中にあれば、通信パスがブロックされる。従って、位置決定問題を解決する技術は今日ない。
【０００８】
【発明が解決しようとする課題】また、低速度データ「通信」アプリケーションも存在する。低速度データ通信を提供する現存するシステムとしては、ページング（無線呼出し）技術がある。ページングシステムの中には建物内の無線カバレッジが悪い場合が多く、また、トランザクション毎にサービスプロバイダに課金される場合もある。また、無線データＬＡＮを建物内に用いる場合があるが、高価である。更に、現在の低速度データ通信技術は上のセキュリティ、位置決定問題を解決しない。本発明は、セキュリティ、位置決定、低速度データ通信アプリケーションの各問題を解決するようなシステムを提供することを目的とする。
【０００９】本明細書では、変調バックスキャッタを用いた無線周波数識別システムがどのように単一のシステムで単一のインフラでセキュリティ、位置決定、低速度データ通信アプリケーションの各問題を解決するかを開示する。本発明は、建物内又はキャンパス領域の位置や通信サービスでの低コストなセキュリティを改善できる。生来的に低コスト技術であるＲＦＩＤ技術を振り返ってみたが、特定の読みとり装置を通過する際のタグを識別する目的でセキュリティ分野において実装することが有望である。建物内やキャンパス環境において、位置決定情報、低速度無線データ通信情報を与える低コスト技術はない。また、質問、位置決定、低速無線データ通信（又はメッセージング）を１システムにて統合して提供するシステムはない。本発明は、変調バックスキャッタを用いる低コストパーソナル通信装置の設計を開示する。本装置は、セキュリティ、位置決定、メッセージングの各機能を単一システムにて単一インフラにて統合して用いることができる。このように本装置は、セキュリティを改善し、低コストのビル内又はキャンパスにおける位置決定及び通信サービスを提供することを目的とし

ている。、

【００１０】

【課題を解決するための手段】本発明の無線通信装置は、変調無線信号を受信し、変調バックスキャッタ技術を用いて変調無線信号を送信することができる。本装置は、本装置から義務的データ群が送信される質問モードと、本装置のおおよその位置を決めることができる位置決定モードと、及び本装置とデータを双方向通信できるメッセージングモードの３つのモードで動作することができる。本装置は変調バックスキャッタ技術を用いて１以上のデータ速度で情報を送信することができる。本装置は、送信されたデータを表示できる表示装置を有する。プッシュボタンをサポートして本装置へデータを入力することもできる。電池、電荷蓄積装置、太陽電池、コイル等のエネルギー変換装置によって本装置に電源を供給できる。電源が充電を必要なときには充電ステーションを用いる。

【００１１】本通信装置は、（Ａ）第１情報信号の回復を行うことができる、受信変調無線信号の変調器と、（Ｂ）前記第１情報信号に応じて、少なくとも２つの代替動作（動作Ａ及び動作Ｂとする）の選択された１つを指示する出力を供給する第１判断要素と、（Ｃ）前記第１情報信号の少なくとも一部を表示する表示装置と、（Ｄ）前記判断要素の出力に応じて、第２情報信号を生成する信号生成装置とを有し、前記第２情報信号は、データ速度を有し、このデータ速度は、動作Ａが指示されたときの方が動作Ｂが指示されたときよりも大きく、（Ｅ）前記第２情報信号を用いて、受信変調無線信号の反射を変調するバックスキャッタ変調器とを有する。

【００１２】

【発明の実施の形態】

ＭＢＳ動作

図１は、この発明を適用を示すのに適したＲＦＩＤシステムの一実施例の全体ブロック図を示すものである。アプリケーションプロセッサ１０１は、ローカルエリアネットワーク（ＬＡＮ）１０２（有線又は無線）を介して複数の質問器１０３、１０４に通信する。質問器それぞれはさらに、タグ１０５～１０７のうちの一つ又は複数と通信する。たとえば、質問器１０３は、情報信号を、たとえばアプリケーションプロセッサ１０１から受信する。質問器１０３はこの情報信号を取り入れ、プロセッサ２００（図２参照）は、タグに送信するのに適した形式のダウンリンク・メッセージ（情報信号２００ａ）を生成する。図１、２において、２０１は無線信号を合成し、変調器２０２はこの情報信号２００ａを無線信号上へ変調し、２０３はこの変調信号を２０４を介してタグへと送る（ここでは振幅変調で）。振幅変調を用いるのはタグが単一の廉価な非線形デバイス（ダイオード等）によって復調できるからである。

【００１３】タグ１０５（図３参照）では、アンテナ３０１（通常、ループアンテナ又はパッチアンテナ）が変調信号を受信する。この信号は、検出器／変調器３０２によって直接にベースバンドに復調される。検出器／変調器３０２は、たとえば一つのショットキー・ダイオードである。ダイオード検出器の出力は入力信号の直接のベースバンドの復調にほぼなっている。３０４は質問器がマンチェスタ符号化を用いてＡＭ信号を送るようにすることにより拡張できる。

【００１４】得られる回復信号３０４ａはプロセッサ３０５へ送信され、ここで回復信号３０４ａが解析される。即ち、プロセッサ３０５は情報信号２００ａの内容を検査する。ここで、プロセッサ３０５はタイミング情報を与える水晶発振器３１２を有する。一態様では、プロセッサ３０５は通常、廉価な４ビット又は８ビットのマイクロプロセッサであり、クロック回復回路３０４は、ＡＳＩＣ（特定用途向け集積回路）によって実装され、これはプロセッサ３０５と協力して動作する。本明細書では、「プロセッサ」は、プロセッサ、マイクロプロセッサ、ＡＳＩＣ等を含む。

【００１５】情報信号２００ａの内容に依存して、プロセッサ３０５は別の情報信号３０６を生成し、これはタグ１０５から送信され、質問器１０３へと戻される。情報信号３０６は変調器制御回路３０７への入力として供給され、これは情報信号３０６を用いてサブ搬送周波数源３０８が生成したサブ搬送信号３０８ａを変調する。一態様において、サブ搬送周波数源３０８は水晶発振器３１２により得られるか、又は、水晶発振器３１２はプロセッサ３０５と分離している。別の態様では、周波数源（プロセッサ３０５の主クロック周波数の分割器等）がプロセッサ３０５内部に存在する信号から得られる。

【００１６】変調器制御回路３０７は、変調サブ搬送信号３１１を出力し、これは検出器／変調器３０２により用いられ、ダウンリンク信号２０２ａのＣＷ無線信号を変調し、これにより変調バックスキャッタ（例えば、反射された）信号３０１ａを作る。ここで、タグから質問器への伝送をアップリンクとしている。このように、変調バックスキャッタ信号はアップリンク信号を構成する。

【００１７】一態様では、変調サブ搬送信号３１１の存在（欠如）は、検出器／変調器３０２（例、ショットキーダイオード）がアンテナ３０１の反射（インピーダンス）を換えることになる。例えば、アンテナのインピーダンスは、０から無限へと変わる。

【００１８】電池３１０によりタグの回路へ電源を供給する。本明細書では、「電源」は、電池、マイクロ波又は電磁エネルギーを電気エネルギーへ変換することのできるデバイス（例、整流器、誘導カップリング）等を含む。

【００１９】単一の周波数サブキャリアを用いる変調バックスキャッタ（ＭＢＳ）には数々の利点がある。例え

ば、サブ搬送の位相シフトキー（ＰＳＫ）（例えば、ＢＰＳＫ（バイナリＰＳＫ）、ＱＰＳＫ（直角位相ＰＳＫ）、より複雑な変調方法（例えば、ＭＳＫ（最小シフトキー）、ＧＭＳＫ（ガウス最小シフトキー）））がある。

【００２０】図２に戻って、質問器１０３は、反射され変調された信号を受信アンテナ２０６で受信し、その信号を低ノイズアンプ２０７で増幅する。そして直交(quadrature)ミキサ２０８内のホモダイン検出を用いてその単一サブ搬送波の中間周波数（ＩＦ）に復調する。（質問器の設計によっては、送信アンテナ２０４と受信アンテナ２０６とを兼ねた一つのアンテナが使用される。その場合は、受信器チェーンで受信された送信信号をキャンセルするための電子的方法が必要である。これはたとえばサーキュレータ等のデバイスによって実現できる。）送信チェーン手段で使用した無線信号源２０１と同じものを使用して、ホモダイン検出を使用してベースバンドへの復調がなされる。これは、受信回路の位相ノイズを減少させるという意味で有利である。それから、ミキサ２０８は復調信号２０９を適当にフィルタするためにその復調信号２０９を（直交ミキサを使用する場合は、Ｉ（同相）信号とＱ（直交相）信号の両方を）フィルタ／アンプ２１０に送る。出力のフィルタされた信号は、（それから、典型的にはＩＦサブ搬送波上で搬送される情報信号２１１が、）サブ搬送復調器２１２でサブ搬送波から復調する。次にサブ搬送復調器２１２は、メッセージの内容を判定するために情報信号２１３をプロセッサ２００に送る。サブ搬送復調器は、複雑な応用においては単純なＡ／Ｄ変換器とディジタルシグナルプロセッサ（ＤＳＰ）を用いて実装される。例えば、振幅変調サブ搬送に対してはダイオードが用いられ、ＰＳＫ変調サブ搬送に対してはＤＳＰが用いられる。復調信号２０９のＩチャネルとＱチャネルは、フィルタ／アンプ２１０もしくはサブ搬送復調器２１２内で結合されるか、又はプロセッサ２００で結合されることも可能である。別の態様では、質問器は、無線信号を送受信するために単一のアンテナを有する。この態様では、受信器連鎖により受信したものから送信信号を分離する電子的な方法が必要である。このことは、サーキュレーターのようなデバイスにより実現できる。

【００２１】上の技術等を用いて、小範囲、双方向のディジタル無線通信チャネルを実装できる。ショットキーダイオード、信号強度ブースト用アンプ、ビットフレーム同期回路、４又は８ビットマイクロプロセッサ、サブ搬送生成回路、電池等を用いて低コストなシステムを作ることができる。ビットフレーム同期、サブ搬送における回路は、マイクロプロセッサコアの周辺のカスタムロジックにより実装してもよい。従って、これらの機能はかなり低コストで提供できる。

【００２２】狭帯域動作

上の手順を用いて、双方向ディジタル無線通信チャネルを作ることができる。このチャネルの範囲はなるべく拡張できた方がよい。このことは、ダウンリンク、アップリンク双方の範囲を拡張することを伴う。

【００２３】ダウンリンクの範囲を拡張することは、幾つかの因子を伴う。第１に、ダウンリンクの範囲は、信号損失を最小化することにより拡張できる。上述のように一態様においては、ダウンリンクは振幅変調信号であり、これは容易に単一非線形デバイスである検出器／変調器（マイクロ波、ショットキーダイオード等）により検出できる。アンテナ３０１から非線形検出変調器への信号損失を最小化するために、アンテナからダイオードへのインピーダンスを整合させることは重要である。第２に、ダウンリンクのデータ速度は、ダウンリンク信号の雑音バンド幅を減らすために制限することができる。

【００２４】第３に、タグのアンテナ３０１は、アンテナバンド幅の外のＲＦ信号をフィルタリングして除くように用いることができる（ＲＦ信号の受信の他に）。例えば、２．４５GHｚでは、許容ＲＦ搬送周波数は、２．４００～２．４８５GHｚである。パッチアンテナ等のアンテナの設計は、この周波数バンドをカバーするが、この範囲を超える周波数をフィルタリングして除く。理想的な周波数応答は、許容周波数範囲をまたがる３ｄＢの間のアンテナ感度で、この範囲を超えると急激に落ちるものがよい。更に、アンプ３０３はアップは期待ダウンリンクデータ速度（典型的には、数ｋｂｐｓ～数十ｋｂｐｓ）の周辺の特定のパスバンドの間の信号のみ通過するように設計されているという点で、フィルタとしても機能する。上述のタグ設計は、変調スキームが主に一定のエンベロープである、アンテナの周波数バンド内のＲＦ伝送にはあまり影響を与えない。このように、このようなタグ設計は、多くの潜在的な干渉信号に抵抗性のある堅牢なタグを可能にする。

【００２５】また、アップリンクの範囲を拡張することは、幾つかの因子を伴う。第１に、アップリンク信号の雑音バンド幅は、可能な限りデータ速度を遅くすることにより減らすことができる。もしアップリンク信号のデータ速度を数ｂｐｓに抑えれば、実装できる有用なアプリケーションの数を大きくできる。データ速度の制限は、単一サブ搬送周波数上に変調データがないような極限にする事ができる。このような場合、このサブ搬送周波数にて受信した信号がごく少ないないし皆無なことは、前のメッセージに対し、「確認」又は「非確認」を指示させる。

【００２６】サブ搬送信号は比較的正確に決定できる。一態様において、サブ搬送周波数源３０８は比較的正確な周波数のサブ搬送信号を生成する。例えば、サブ搬送周波数源３０８は周波数３２ｋHｚで精度±１００ｐｐｍ（即ち、水晶発振器の周波数は±３．２Hｚの間）の廉価な水晶発振器を用いることができる。

【0027】一態様において、ＤＳＰ等のプロセッサ２１０ａを用いる質問器において狭帯域フィルタリングが実装され、フィルタ／アンプ２１０とサブ搬送復調器２１７の機能を行う。この態様では、プロセッサ２１０ａは公知の狭帯域フィルタリングアルゴリズムを用い、１０Ｈｚより小さいバンド幅の信号のディジタルフィルタリングを行い、第１サイドローブは、６０ｄＢへと抑えられる。次に、このプロセッサ２１０ａが受信した信号の信号強度が測定され、この強度は信号がない時のそのチャネルにおける平均雑音よりも十分に上の基準信号強度と比較され、望まない信号が実際の信号と誤解されないようにする。この方法により、非常に弱いアップリンク信号も信頼性を持って検出できる。この技術を用い、ダウンリンクとアップリンクにおいて大まかに同等な範囲を達成できる。

【0028】次に、サブ搬送周波数ｆsの位置を議論する。ＭＢＳシステムは任意の数の反射体からのＲＦ源の反射によるアップリンク信号における雑音を示す。通常、反射体には２種類ある。即ち、信号が送信された搬送周波数と同じ搬送周波数で信号を反射する反射体、及び信号が送信された搬送周波数とは異なる搬送周波数で信号を反射する反射体である。前者の種類には、壁、金属物体がある。これらの反射体から反射した信号は、搬送信号に対して任意の位相関係を有する。反射を相殺するには、ホモダイン検出器として動作する直交ミキサ２０８を用いる。後者の反射体の種類は、ドップラーシフト（移動する金属物体により起こる）又はサブ搬送周波数付近の周波数にて動作する電子機器からの反射により生成される。難しい問題として、蛍光による光の雑音があり、基本波６０Ｈｚの周波数（米国で）だけではなく、数千Ｈｚよりも大きい可聴音を超えた周波数の雑音を作る。サブ搬送周波数ｆsが基本波６０Ｈｚの周波数の倍数に落ちるように位置させることが解決法として知られている。一態様にて、３２ｋＨｚの水晶発振器がこの要件を満足するサブ搬送周波数を生成するのに用いられる。

【0029】多モード動作

一態様にて、取扱システムは多モード動作が可能である。この態様では、タグと質問器は高データ速度と低データ速度にてデータを送信できる。他のデータ速度も可能である。一態様では、実際のデータメッセージ（例、多ビット、高ビットメッセージ）が高データ速度モードを用いて取扱システムにより送信、受信され、確認メッセージ（例、１ビット、低ビットメッセージ）が低データ速度モードを用いて取扱システムにより送受信される。

【0030】好都合なことに、低データ速度モードは、拡張した範囲を本発明の取扱システムに与える。前述のように、通常１ビット又は低ビットの確認メッセージを送信するのに低ビット速度モードが用いられる。このことにより、確認メッセージが実際のデータメッセージよりも小さい周波数バンドで送信される。周波数バンドを小さくすれば、周波数バンドの外の雑音の狭帯域フィルタリングのアプリケーションを可能にし、このことにより、確認メッセージを送信できる範囲を拡張できる。

【0031】前述のように、１ビットの情報を送るため、タグは、入信号（反射連続波無線信号）上へ変調バックスキャッタを用いて変調できる非変調サブ搬送周波数を生成することができる。そして、質問器は、単一周波数音の反射信号を受信する。次に狭帯域フィルタリング技術を用いて、雑音バンド幅を減らしこの信号の存否を決定するのに用いることができる。

【0032】動作に入ると、タグ１０５はダウンリンクメッセージとして質問器１０３から送られた情報ビットを検知し組み立てる。同期パターンビットをダウンリンクメッセージの開始時に送信する。これらのビットはタグがビット及びメッセージ同期を獲得することを可能にし、ダウンリンクメッセージの開始及び終了をタグが決定することを可能にした。一態様では、ダウンリンクメッセージは、アドレス、コマンド、また、データ及びエラー検出、訂正等の情報を含む。ダウンリンクメッセージのコマンド又はデータ部分は、タグ１０５が実データメッセージ（タグＩＤ他のアプリケーション依存データ等）又は確認メッセージ（１ビット確認メッセージ等）を返すべきかを指示すべきである。

【0033】タグ１０５のプロセッサ３０５は、どの種類のアップリンク信号を質問器へと送り返すべきかを決める。タグ１０５が実データメッセージ又は確認メッセージのいずれかを送信して質問器１０３がこれら２種類のメッセージを受信し区別できるようにする方法には幾つかある。図３に戻ると、一態様において情報信号３０６はプロセッサ３０５からリード３０６ａを介して変調器制御回路３０７へと送信される。タグ１０５のプロセッサ３０５が１情報ビットからなる「単一音」メッセージを送る場合、リード３０６ａは情報メッセージを送るべきでないことを指示する第１論理状態に維持され、これにより変調器制御回路３０７は非変調サブ搬送信号３１１を出力させるようにする。プロセッサ３０５が実データメッセージを送る場合、リード３０６ａは変調器制御回路３０７へと実データメッセージを運ぶ。この実データメッセージは次に、振幅変調、位相変調、周波数変調、符号変調等の変調技術を用いてサブ搬送信号３０８ａを変調するのに用いられる。

【0034】図２に戻り、質問器１０３は受信アップリンク信号から、変調（又は非変調）サブ搬送信号を受信し復調し、そしてフィルタリングを課す。サブ搬送周波数の詳細を与えると、適切なフィルタ／アンプ２１０が雑音を除去する。次にサブ搬送復調器２１２はもしあれば情報信号３０６を変調（又は非変調）サブ搬送信号から復調する。次にプロセッサ２００は情報信号３０６を

復号するのに必要なディジタルシグナルプロセッシングを行う。プロセッサ２００はＤＳＰを用いてもよいが従来のマイクロプロセッサも用いてもよい。

【００３５】単一サブ搬送音を有する「単一音」確認メッセージを回復するため、フィルタリングアンプは、狭帯域フィルタとする。従来のフィルタ技術も用いることができるが、上のＤＳＰ２１０ａを狭帯域フィルタに用いるとよい。この単一音のサブ搬送周波数は、タグ１０５が周波数源として廉価な水晶を用いるので周知である。水晶の精度が多少悪くても、サブ搬送周波数は数Ｈｚの精度であり、非常に狭帯域なフィルタリングを可能にする。タグ１０５からの確認メッセージ応答がＲＦＩＤシステムの範囲を拡張するのに用いられ、弱い信号である可能性が高いので、フィルタ／アンプ２１０の狭帯域フィルタには更なる任務を課した。

【００３６】ＤＳＰを用いる態様として、アップリンク信号の周波数成分を動的にサーチすることがある。このことは図２のプロセッサ２００を用いて入データ流にフーリエ変換を行うことにより行える。変調サブ搬送信号を表す複数の信号を微分しても、知らないデータ速度の単一サブ搬送信号をフーリエ変換して回復させて複数の信号をサーチできる。

【００３７】このように、変調バックスキャッタ通信システムが２つのモードにて動作させる方法を示した。１つはバックスキャッタ信号が高データ速度アップリンク通信チャネルを提供するように変調されるモードであり、１つはバックスキャッタ信号が低データ速度アップリンク通信チャネルを提供して単一音等の確認信号を長距離からでも検知できるように変調されるモードである。

【００３８】多モードの実装

取扱システムの多モード動作は３つのサービスにより実装される。第１のサービスは、「質問」サービスである。質問器がタグへダウンリンクにて「質問信号」を送信することにより質問は始まる。タグは受信質問信号を復号し、復号した質問信号に基づいて行動を決める。「標準的な」質問の場合、タグは、ＭＢＳを用いて質問器へ「義務的データ(mandatory)」を返すことを要求される。「標準的な」質問を受信する質問器の読みとりフィールドにいるタグはそれぞれ、その義務的データにより後に説明するプロトコルを用いて応答する。「読みとりフィールド」は、タグと質問器が通信できる空間領域をいう。また質問器は、「標準的な」質問サービスの一部として、タグそれぞれ全てのために意図されたデータを送信する。このようなデータの例としては、時間情報、フレーミング情報他の同期情報等がある。義務的データは識別情報を有してもよい。、

【００３９】「標準的な」質問を超える他の質問も可能である。例えば、質問器は、質問を用いて特定のタグを識別した後、タグのメモリに記憶される更なるデータをそのタグへと送信することができる。質問器はタグが他のデータをその質問器へと送信し返すことを要求してもよい。これらの更なるデータの通信には、「標準的な」質問において用いたデータレートを用いることができる。従って、タグそれぞれ全てへとコマンド及びデータを送信するために質問器を用いて、読みとりフィールドにおける特定のタグを識別し、そのタグと双方向で通信できる。質問において、ダウンリンクに要するデータ速度は通常大きくない。なぜなら、質問信号は読みとりフィールドの全てのタグが応答することを要求するのに必要なビットのみを持っていればよいからである。ダウンリンクにおけるデータ量と比べてアップリンクのデータ量は通常かなり大きい。義務的データは時間が重大（クリティカル）である送信においてしばしば送信されるので、アップリンクのデータ速度はダウンリンクのものよりもかなり大きい方がよい。即ち、ダウンリンクデータ速度がアップリンクデータ速度より小さいような非対称性がある。

【００４０】第２のサービスは、「位置（位置決定）」サービスである。これはタグの位置を位置決定するのに用いられる。位置決定において、質問器はダウンリンクに「位置決定信号」をタグへと送る。これは位置決定信号が向かう特定のタグのアドレスを有する。このサービスでは、タグは単純な確認メッセージ（一定音信号等）により応答するように要求される。上の狭帯域技術を用いて、質問サービスの範囲を遙かに超えた範囲にて質問器によって一定音信号を受信できる。従って、ダウンリンクがアップリンクよりも大きなデータ速度である非対称通信サービスが存在する。

【００４１】位置決定サービスは以下のように特定のタグ１０５の位置を決める。取扱システムはタグの位置の情報を持っていないとする。質問器は位置決定信号を送信し、そして可能性のある応答（確認メッセージ）を聴く。各質問器は受信応答（もしあれば）の信号強度を決めることができ、ＬＡＮ１０２又はアプリケーションプロセッサ１０１の位置決定プロセスへとそれらの決定を報告する。ここで、位置決定プロセスは、質問器により位置決定プロセスへと報告される確認メッセージの信号強度に基づいてタグの位置を決めることができるソフトウェアプロセスである。位置決定プロセスは、タグの位置が最強の確認メッセージ信号強度を受信する質問器の位置と等しいものとして決める。ここで、タグの位置の精度は質問器の有効範囲である。

【００４２】別の態様では、位置決定プロセスは、もし２以上の質問器が確認メッセージを受信した場合はタグの位置を決定するのにより複雑な方法を用いる。タグの位置は、確認メッセージを受信した質問器、及び各質問器の空間位置に基づいて決められる。例えば、もし２つの質問器が等しい信号強度の確認メッセージを受信した場合、タグの位置はこれら２つの質問器の２等分線上に

あると推定できる。もし３つの質問器が確認メッセージを受信した場合は、「三角位置決定」が可能となる。文献、'The NLOS Problem in Mobile Location Estimation Proceeding 1996 5th International Conference on Universal personal Communic. oct 96' by Marilynn Wyle and Jack Holtman、を参照するとよい。

【００４３】第３のサービスは、「メッセージング」サービスである。「メッセージング信号」と呼ぶダウンリンク信号は、１以上のタグのアドレス、及びこれらのタグのためのデータを有し、質問器により送信される。メッセージング信号のタグアドレスと合致するタグはそのデータをプロセッサ３０５に関連づけられたメモリ３０５ａへと記憶するように、またそのデータを用いて他の機能を行うように指示される。タグがメッセージング信号に応答する方法には幾つかの方法がある。メッセージング信号がタグにデータを記憶するように指示すれば、タグは、質問器へと確認メッセージを送り返すことによりメッセージング信号の受領を確認させる。代わりに、もしメッセージング信号がタグに判断をすることを指示、又は質問器へ他のデータを送り返すように指示すれば、数ビットのデータの確認メッセージにより応答する。従ってメッセージングにおいては、もしアップリンクが確認メッセージであれば、ダウンリンクがアップリンクよりも大きなデータ速度を有するような非対称通信パスが存在することとなる。

【００４４】別の態様では、上述のサービスの１つで始まり別のサービスへと換えることができる。以下にこのような通信を可能にする方法を説明する。タグとの通信を望むとする。メッセージングサービスが質問器からタグへと送信され、質問器で受信される単純な確認によりタグが応答することを指示する。更に、質問器が受信した確認メッセージに基づいて、質問器は更なるデータをその質問器へとタグが送り返すようにタグに指示したいとする。例えば、質問器はもし信号強度がしきい値よりも低ければ確認メッセージの信号強度を決め、メッセージングサービスのためにアップリンクにて通常用いるデータ速度までにアップリンクデータ速度を制限する。信号強度はしきい値よりも上である他の場合は、質問器は質問サービスのためにアップリンクにて通常用いられるデータ速度までにアップリンクデータ速度を変える。ここで、２つのアップリンクデータ速度を用いて説明したが、他のデータ速度も用いることができる。

【００４５】一態様にて、上の３つのサービス全ては、同じシステムにおいて共存し、同時に動作させる。これらのサービスは、必要なデータ速度に基づいて、質問器からタグへの異なる範囲をサポートするということを認識することから始める。例えば、質問サービスには、タグが質問器のそばを通る時等に短時間において相当な量のデータ伝送を伴う。ある時において読みとりフィールドにいくつもタグが存在するときには必要なデータ速度は更に増える。データを同時に伝送する複数のタグが同時に存在すれば、お互い干渉せずに複数のアップリンクを可能にするためにはプロトコルが必要である。一態様において、アロハ(Aloha)又はスロテッドアロハ(Slotted Aloha)のプロトコルを用いる。質問サービスの通常のデータレートは、５０～３００ｋｂｐｓの範囲である。ここで、他の因子がないことにより、範囲とデータ速度は相反する関係で、トレードオフすべきことに留意する。文献、'Queuing Systems Vol. 2 Computer Applications' by Leonard Kleinrock, published by John Wiley & Sons, NY in 1976、を見るとよい。

【００４６】まとめると、データ速度には２つの異なる「非対称性」がある。即ち、質問サービスにおけるアップリンクの方がダウンリンクよりも大きなデータ速度の場合、及び位置決定及びメッセージングサービスにおけるダウンリンクの方がアップリンクよりも大きなデータ速度の場合である。従って、質問サービスの有効範囲は位置決定又はメッセージングサービスのものよりも小さい。なぜなら、質問サービスにおけるアップリンクのデータ速度要件はより大きいからである。この範囲における差違を図４に示した。これらのデータ速度の間の関係を観測することは重要である。上の「範囲拡張」の章では、狭帯域フィルタリングを用いて相当な範囲拡張を達成できたことを示した。位置決定及びメッセージングサービスはダウンリンクがおおまかに数ｋｂｐｓのデータ速度であり、アップリンクは数ｂｐｓである。質問サービスはダウンリンクがおおまかに数ｋｂｐｓのデータ速度であり、アップリンクは５０～３００ｋｂｐｓである。

【００４７】これら３つのサービスは本装置の１つの有用で廉価なエンドユーザーデバイスによりサポートされ実装される。この装置をパーソナルページャー識別装置（ＰＰＩＤ:personal pager and identifier）と呼ぶ。図４にはＰＰＩＤのブロック図を示した。

【００４８】アンテナ４０１はパッチ又はループアンテナである。パッチアンテナを用いると、ＰＰＩＤ装置の基板へメッキでき、基板の背面を接地面として用いることができる。外側に向けられたアンテナパターンを作るようにするとよい。即ち、接地面から離れた方向へである。ＰＰＩＤは小さいので、また無線周波数伝搬のため、マイクロ波周波数のＲＦ信号を用いるとよい。即ち、２４５０ＭＨｚを用いるとかなり小さいパッチアンテナを提供できる。

【００４９】従業員バッジとして装着されたＰＰＩＤ装置は、従業員の前側の無線通信が最適になるようにする。これにより、質問器はＰＰＩＤと速やかに無線接触できる。アンテナ４０１と検出変調器４０２、そしてアンプ４０３の設計は重要である。位置決定モード、メッセージングモードのために要求されたダウンリンク範囲を提供するために、アンプ４０３は非常に弱い復調ＡＭ

信号をCMOSレベルまでブーストできなくてはならず、これはとても大きなダイナミックレンジで動作し、非常に小さな電流しか用いない。積分するとアンプ403は多くても数μAの電流分しか流さない。

【0050】プロセッサ404は、電流消費がμA以下であるスリープモードと、mAを遙かに下回るアクティブな電流消費状態のウェークモードを有する。プロセッサ404はPPIDの頭脳であり、ダウンリンク信号を復号し、要求されるアップリンク応答の種類を決める。プロセッサ404は水晶発振器430、又はプロセッサ404内の発振器により同期される。

【0051】ここで、図4のPPIDと市場で出回っているものとは類似点があることがわかる。四則演算計算機を考える。廉価なクオーツ時計を考える。アンテナ401、検出変調器402、アンプ403、サブ搬送変調器405、サブ搬送周波数源406等は市場で出回っているものにはない。ページャーとPPIDは似ているように思える。しかしページャーはページングシステムの範囲を得るための無線回路のおかげで高価であり、双方向ページャーは更に高価である。本発明は、ページャー等に機能を取り入れたのではなく、廉価な技術により創造される。PPIDが大きな表示装置を必要である場合もあるがこの場合においても廉価である。

【0052】PPID物理的設計
PPID設計の例を図5に示した。

【0053】パワー管理
電池を減らさないようにパワー管理は重要である。

【0054】認証及びセキュリティ
高度のセキュリティ環境においては多くの認証及びセキュリティ技術がある。

【0055】PPID動作能力
従業員がビルに入ると、質問器103はこれをモニタリングし、質問モードを用いてPPIDとの無線通信を確立する。そして、時間や日付のようなデータをPPIDに送信し、PPIDは無線通信システムと時間同期される。質問器はアプリケーションプロセッサ101に特定のPPIDが質問を受けたこと、及び質問時間スタンプを報告される。ビル内の他の質問器も規則的に質問モード信号を送信する。即ち、PPIDが範囲内で信号を受信すると上述の義務的データを含むアップリンク信号を送信する。質問モードによりPPIDと通信できる他の質問器103はそのことを質問時間スタンプと共に通信する。従って、PPIDの位置の時間履歴が位置データベース110に構築される。質問モードの有効範囲は、位置決定モードやメッセージングモードの範囲よりも小さいので、特定のPPIDのデータベース履歴は、PPIDが質問モードの範囲外にある場合もあるという意味で、連続的でない。従って、質問モードの通信は幾つかの結果を生む。第1に、質問モードはビルへの最初の入館を認証するのに用いられる。第2に、質問モードはビル内の他のドアウェーの通過に際し認証するのに用いられる。第3に、質問器によってビル全体で質問モードモードを用いて、連続的ではないがPPIDの大まかな位置の時間履歴を作ることを可能にする。

【0056】PPID400の位置を知りたいとする。その要求はアプリケーションプロセッサ101へ通信リンク130を介して送られる。アプリケーションプロセッサ101はまず、位置データベース110を検査してPPID400の位置を得た最新の時間を確認する。位置決定が最近（時間を経たずに、の意）されていなければアプリケーションプロセッサ101はこのPPIDの位置は未知であることを決定し、位置決定モード信号が全ての質問器により送信され、PPIDの応答を要求する。もしPPIDの位置決定が最近なされていれば、前に決定した位置の近くの質問器のみが位置決定モード信号を送信する。次に質問器103はアプリケーションプロセッサ101へ位置決定モード信号の結果、応答信号を検出できたかを送信する。もし検出できたなら、その信号の信号強度を送信する。次に、アプリケーションプロセッサ101はPPIDの大まかな位置を決めることができ、その情報を通信リンク130を介して要求者へ戻す。

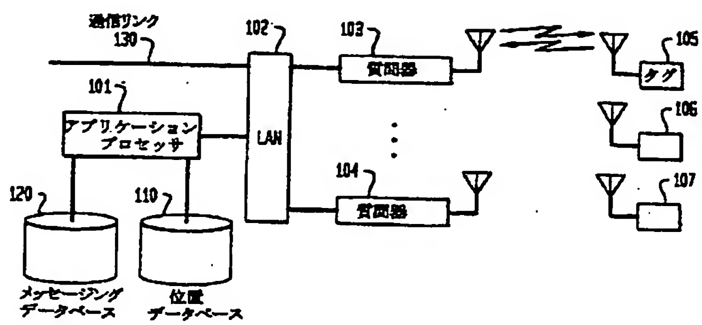
【0057】
【発明の効果】以上述べたように本発明により、セキュリティ、位置決定、メッセージングの各機能を単一システムにて単一インフラにて統合して用いることができた。このように本装置は、セキュリティを改善し、低コストのビル内又はキャンパスにおける位置決定及び通信サービスを提供できた。

【図面の簡単な説明】
【図1】無線周波数識別（RFID）システムの実施例のブロック図。
【図2】図1のRFIDシステムで使用される質問器ユニットの実施例のブロック図。
【図3】図1のRFIDシステムで使用されるタグユニットの実施例のブロック図。
【図4】PPIDのブロック図。
【図5】PPIDの物理的レイアウトの正面図。
【図6】PPIDの物理的レイアウトの正面図。
【図7】PPIDにおけるRF検出器のブロック図。
【図8】ドッキングステーション、及びドッキングステーションに対してどのようにPPIDが配向するかを示す部分透視斜視図。

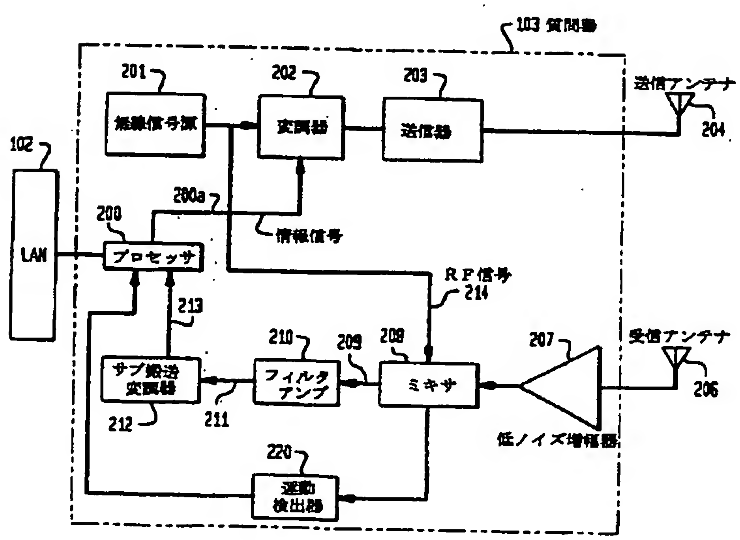
【符号の説明】
101　アプリケーションプロセッサ
102　ローカルエリアネットワーク（LAN）
103、104　質問器
105、106、107　タグ
200　プロセッサ
200a　情報信号

２０１　無線信号源
２０２　変調器
２０３　送信器
２０４　送信アンテナ
２０６　受信アンテナ
２０７　低ノイズアンプ
２０８　ミキサ
２０９　復調信号
２１０　フィルタ／アンプ
２１１　情報信号
２１２　サブ搬送復調器
２１３　情報信号
２１４　信号
３０１　アンテナ
３０２　検出器／変調器
３０３　アンプ
３０４　クロック回復回路
３０５　プロセッサ
３０６　情報信号リード
３０７　変調器制御回路
３０８　サブ搬送周波数源
３１０　電池
３１１　変調サブ搬送信号
３１２　リード

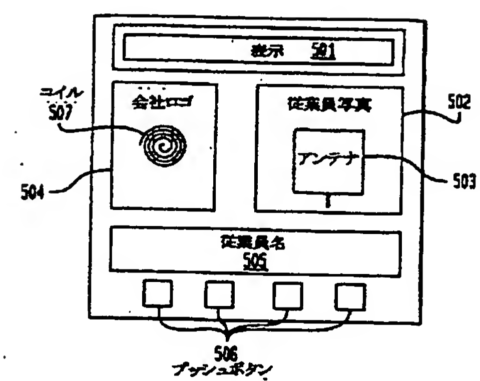
【図１】



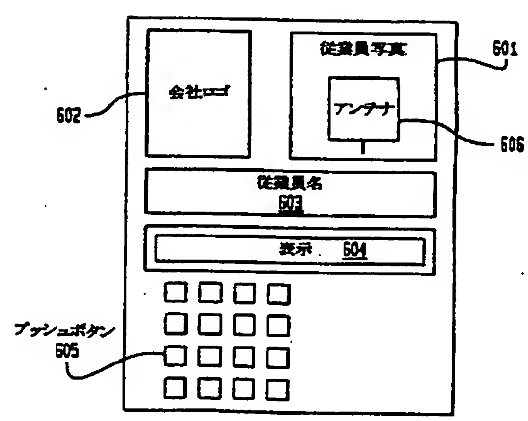
【図２】



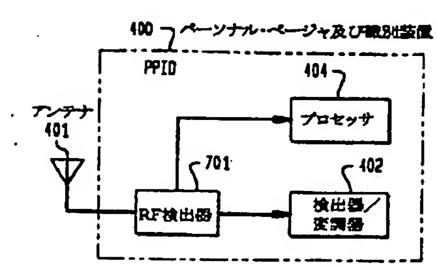
【図５】



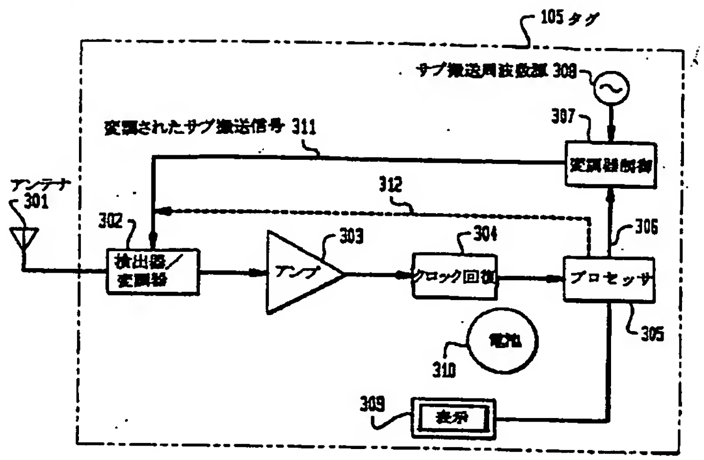
【図６】



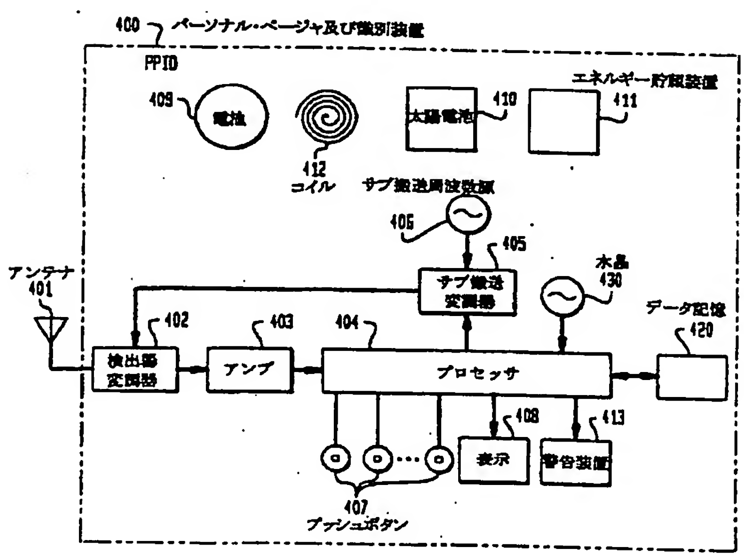
【図７】



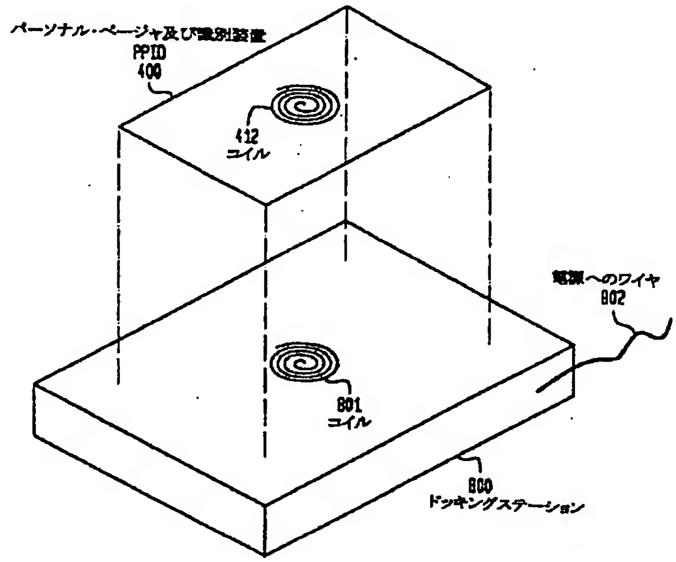
【図3】


105 タグ
サブ搬送周波数源 308
307
変調されたサブ搬送信号 311
変調器制御
312
アンテナ 301
302
303
304
306
検出器／変調器
アンプ
クロック回復
プロセッサ
305
電池
310
309
表示

【図4】


400 パーソナル・ページャ及び識別装置
PPID
エネルギー貯蔵装置
409
電池
410
太陽電池
411
412
コイル
サブ搬送周波数源
406
405
水晶
430
アンテナ 401
サブ搬送変調器
データ記憶
420
402
403
404
検出器変調器
アンプ
プロセッサ
408
413
表示
警告装置
407
プッシュボタン

【図8】



フロントページの続き

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